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WONDERS OF LAND AND SEA

H 1a

The Fleetest of the Fleet

The work of the destroyers here seen tearing through a heavy sea to attack big ships under cover of night, to act as the admiral's eyes and ears, darting ahead to see the position of the foe, seeking for hostile torpedo craft, and wirelessing all the news back to the flagship.

WONDERS OF LAND AND SEA

EDITED BY

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With an Introduction by

SIR H. H. JOHNSTON, G.C.M.G., K.C.B.

And Contributions by Many other Eminent Specialists

* * * *

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I.—On the Land: Natural

Photo R Kearton

A Quiet Backwater

The Courtship of Birds

How Feathered Folk Make Love—The Utility of Fine Feathers—Birds as Devoted Parents

By BENJAMIN HANLEY

As the dark days of winter pass and budding growth in hedgerow and woodland denotes the approach of spring, birds begin to take up their domestic duties, and, naturally, the first step is the choosing of a mate. Courtship amongst birds is as varied and interesting in its forms as amongst humans, and it is pleasing to note the different styles adopted by the several species of feathered folk. Usually it is the male who plays the part of ardent suitor, but there are exceptional cases where bashful birds are wooed and won by feminine charmers.

Some species seem to regard their courtship as a very matter-of-fact procedure, and experience little difficulty in persuading a member of the opposite sex to join them in matrimonial ventures, and whilst choosing their mates these birds indulge in little or no preliminary love-making. Others, apparently, experience considerable difficulty in obtaining a companion, and have to pay court assiduously; whilst yet again others have to fight innumerable battles with rival members of their own sex before settling down to domestic cares. Many of the latter, like our ancestors, practically carry off their brides by force after having defeated their rivals.

In the feathered world the general rule is one mate only, but polygamy is by no means unknown, and, indeed, is the rule rather than the exception with certain

Photo T. A. Metcalfe

Chaffinch and Young in Nest

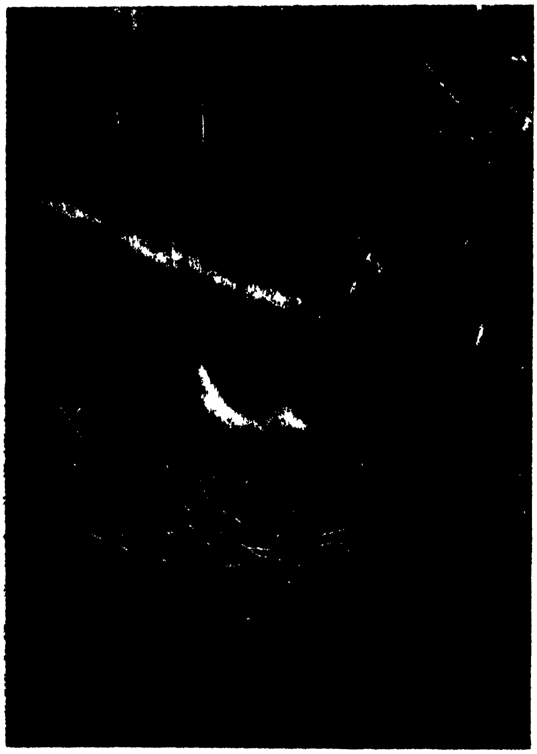


Photo T. A. Metcalfe

Whitethroat Feeding Young

species. Many kinds pair for life, others for two or maybe three seasons; whilst a great number consider themselves free at the end of each season.

Colour plays a prominent part in bird courtship, and, with few exceptions, the male possesses a much more brilliant plumage, the contrast of the sober-hued hen birds being frequently so great that a novice might well be pardoned for concluding the male and female were of entirely different species. The well-known silver pheasant is a good example.

Often, in addition to the normal plumage, which may be quite gorgeous, crests, plumes, feathers, and various other appendages are put on solely for the breeding season; even an entire change of plumage may be effected for the mating season, as in the case of the mallard. A case of a partial change is found in the black-headed gull, which assumes the dark brown hood, from which it takes its name, for the breeding season; and amongst birds which develop special appendages is the ruff. In this case the male has a regular ruff on the neck during the nesting time, which can be erected or extended at will, and from this the bird takes its name. This ruff is used solely as a means of "showing off" before the females.

This displaying of special attractions is indulged in to a greater or less extent by the males of all species where brilliant or high colours are found, and it is when two or more males are paying court to the same dun-coloured female that fierce duels occur. In such cases, although the hen may have been accepting the addresses of the one who proves the loser in the fight, such is her fickle nature or the domineering manner of the victor that she at once accepts the latter until, possibly, a bird even better than he appears on the scene and challenges him to a contest. Thus only the strong and healthy males are able to secure and keep mates, and by this means Nature provides for the survival of

Drawn by P Frenzeny

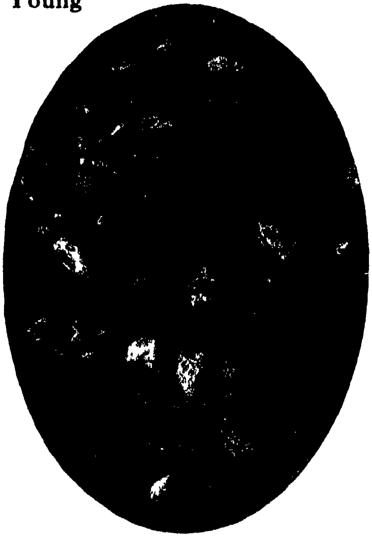
Paradise Birds Courting

When the male Paradise birds assemble in the branches of trees to "show off" their wonderful plumage before the females, the plumage hunter takes advantage of the opportunity to ply his cruel trade. He builds a screen to conceal himself, and from there shoots them down with blunt arrows. In the inset natives are seen smoking the skins for the plumage market

Photo Oxley Grabham

Song Thrush and Young

the fittest. With the game birds such duels are frequently very fierce, and the loser may be severely wounded; but usually the birds only fight by striking each other with wings and feet, and, unless the latter are equipped with spurs, little damage is done.



Black Cap Warbler Feeding Young

The curious antics gone through by many birds when "displaying" is most amusing. They try to show themselves off to their fullest extent, and, in order to do so, assume attitudes which from our point of view appear highly ludicrous or grotesque. Common examples are the turkey-cock of the farmyard and the peacock, the tail or train of the latter showing a perfectly symmetrical distribution of "eyes" when fully extended. Less known is the tail display of the turtle-dove, which flies upward, and after gaining a fair altitude drops almost perpendicularly, spreading its tail upwards in the form of a graceful fan. Indeed the pigeon family, as a whole, are much given to display, and all will have noticed the house varieties strutting about near the females of their choice, bowing low and then spreading out wings and tail and trailing them on the ground, at the same time puffing out their throats to show off the iridescent hues of the feathers round the throat and neck. Often they will keep up this display for hours together. The wood-pigeon or ring-dove, like the turtle-dove, raises its tail when showing off and playing to the hen, and does not lower it down to the ground like the house pigeons. In contrast with these species is the quiet love making of the lapwing or green plover, which stands beside its mate often for long periods without

Photos: T. A. Metcalfe

Grey Linnet and Young

Grey Parrots and Nestlings

(Drawn by G. E. Lodge)

In their natural state the grey parrots, so often seen in cages, nest in the holes of trees, and are ideal parents

Photo: Oxley Grabham

Pheasants versed in the Arts of Coquetry

betraying a single movement, appearing so statuesque that one might well assume they were quite content to be simply in each other's company.

The common rook makes a devoted lover, and may be observed bowing low and spreading his tail proudly before his mate, and also indulging in various wild, fantastic flights. The green plover mentioned above, however quiet it may be on the ground, is a different bird entirely when on the wing, for its weird evolutions are a feature of the low-lying districts in spring, as is also its wild yet musical love song, something like "*Willow-weet-pee-wit.*" The mention of the birds' notes calls to mind the fact that many species have special notes for use solely during the days of their courting. The bird just mentioned, for instance, at other times of the year merely uses the ordinary call note "*Pee-wit,*" from which it gets its popular name; and the grey-backed or hooded crow—a winter visitor to the eastern coast districts of Great Britain—betrays the time for his departure to nesting haunts by interspersing his usual hoarse croakings with more guttural notes. In fact, all the volume of bird song heard in early spring is simply a collection of courting expressions in avian tongues, possibly voiced as much in the nature of a challenge to possible rivals as addresses to the ladies of their choice. Without doubt an exceptionally fluent member of a singing species, like the song-thrush, has more ease in obtaining a mate than one not so gifted; and it is a fact that each victory over a rival seems to lend added brilliancy to his song.

Quite a distinct courting display is that of the snipe. In this case we have the well-known "drumming" or "bleating" sound, which, until recent years, was believed to be produced by the mouth. However, it has now been pretty conclusively proved to be due to the action of the air on the wing and tail feathers. The bird soars to a considerable height, and then

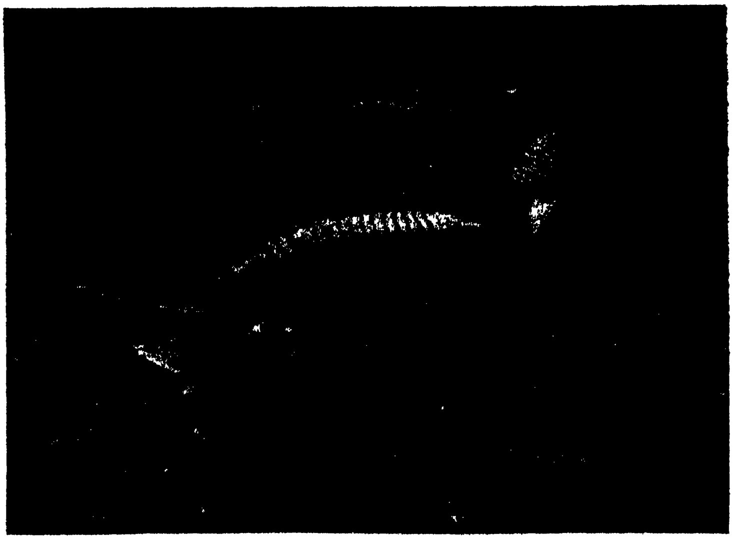


Photo: Oxley Grabham

Lady Amherst Cock Playing to Hen

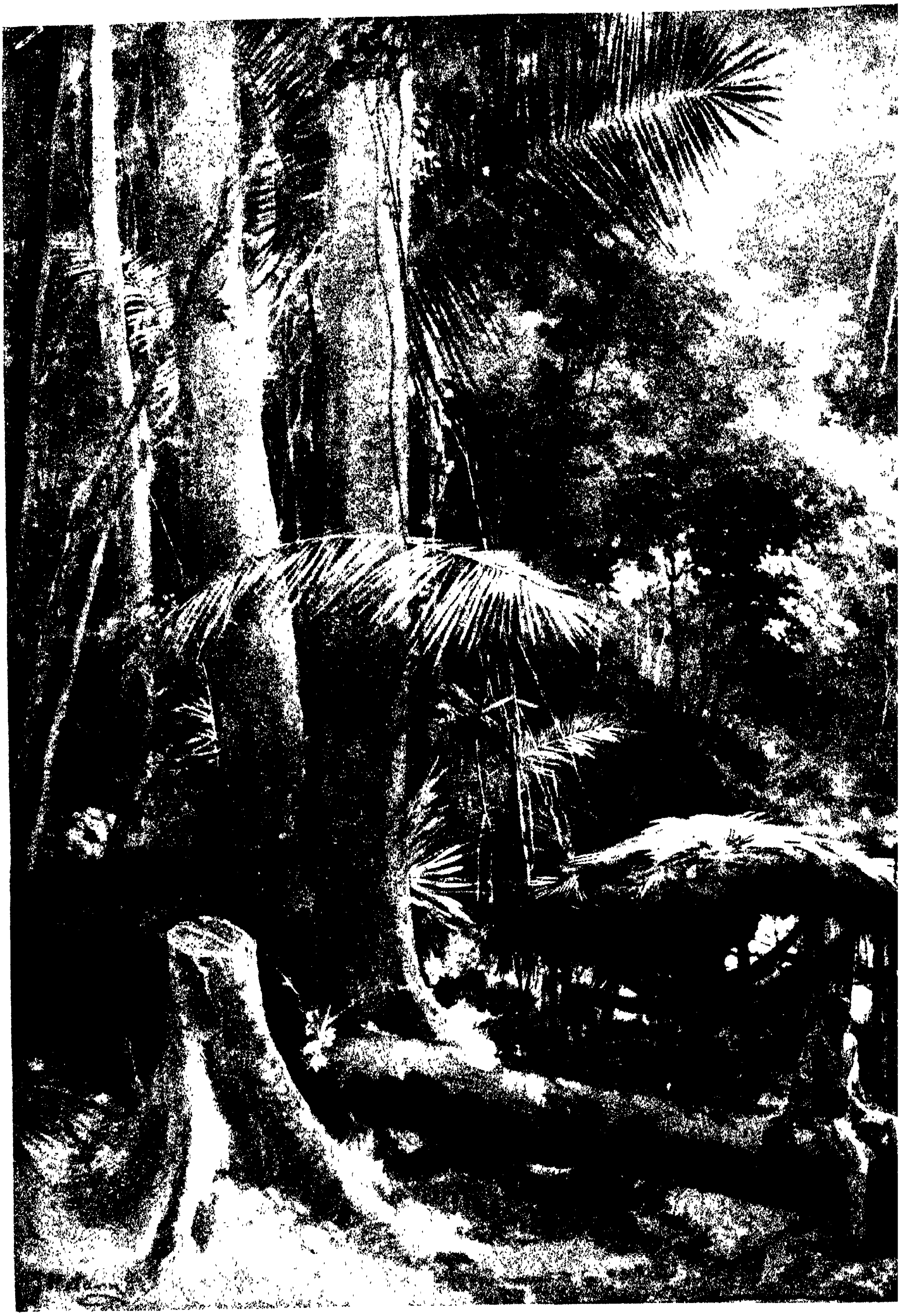
makes a steep descent with great velocity, accompanied by a tremulous movement of the wings and the outspreading of the tail feathers.

Avian courtship is frequently short-lived, and often ends before the nest is fully built. In fact, in many cases the male does not carry so much as a stick or a straw to help in its formation; generally, however, he plays a fair share in this house building, and in some species does nearly all the work. The common wren, for instance, has such a love for the work that he is not content with providing one home for his lady-love, but usually he must needs make several spare ones for which he can have no use, but which serve as sleeping apartments for the nimble woodmice. As a general rule, we find that if the nest is one which takes up a lot of time in preparing, then the male assists, but otherwise he does practically nothing. After the eggs are laid, many birds are most attentive to their sitting mates, and keep them hourly supplied with dainty tit-bits, even taking long turns at incubating the eggs; but, on the other hand, some birds, notably the cock pheasant, make exceedingly bad husbands, for, once the eggs are laid, he pays little or no attention to his mate, and it is an exceedingly rare thing indeed to find him sitting on the nest.

Photo W S Berridge F Z S

Bird of Paradise Displaying

An ideal husband is the dotterel, which undertakes the task of bringing off the young entirely by himself, and indeed will even chase the female away from the nest time after time if she should happen to approach it too closely after the full clutch of eggs has been laid.



IN THE BRAZILIAN JUNGLE A SCENE ON TH

VER ITECOAHY, A TRIBUTARY OF THE AMAZON

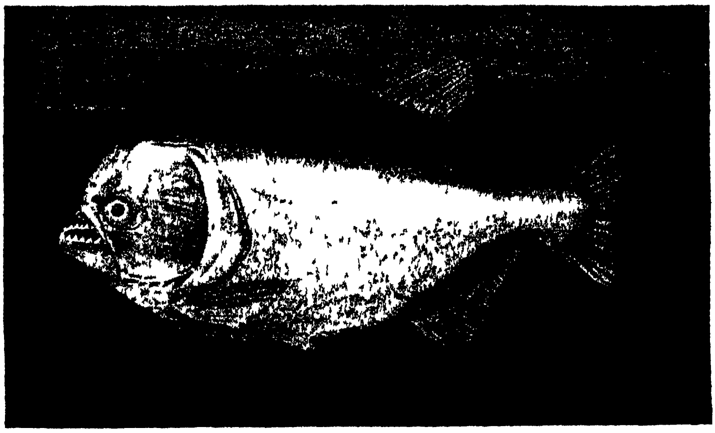
The Cannibals of the Amazons

Concerning the Perai, Piraya, or Caribes of the Amazon—Included in this Section like other Freshwater Fish to Distinguish them from Ocean Dwellers

By CLAUDE E. BENSON

THERE are lots of good fish in the sea, even in those parts of the ocean infested by sharks; there is plenty of life in most great rivers, even where pike abound; but in certain stretches of the rivers of tropical and sub-tropical South America there is peace.

It is in these stretches that the Cannibals of the Amazons live. "*Solitudinem faciunt, pacem appellant.*" They make a solitude and call it peace, to adopt Byron's not very happy version. Where these fiends are, no unarmoured life is possible.



[illegible] by J. H. Fitchew

The Perai—Cannibal of the Amazon

By unarmoured life I mean any creature which is less efficiently protected than an alligator. It has been said, records a popular Natural History, that if even so large an animal as an ox happens to get into one of their shoals, it is immediately assailed and bitten so severely that it may succumb to its injuries before it can cross a stream thirty or forty feet in width. The same author adds, with the utmost gravity, that even living human beings seem to enjoy no immunity from this hungry fish, but to be liable to severe bites while bathing. Why a delicate-skinned human being should enjoy immunity when a tough-hided ox is destroyed is not explained. Neither is it only while bathing that a human being is liable to severe bites—i.e. to be rent into shreds and devoured inside a very few minutes. One of these little demons has been known, according to an unimpeachable authority, to leap a foot out of the water and bite a piece out of a man's hand.

These bloodthirsty water-fiends are the Piraya, Perai, or Caribes. From their appearance the Bulldog fish would not be an unsuitable name. Like the bulldog, they are very heavily built forward, and, like the bulldog, when once the jaw is locked, something has to give before the teeth are disentangled.

One might imagine, from the foregoing fearsome indications, that the Cannibal was a monster of most formidable size and appearance, an equal in bulk to the shark or the alligator. Nothing of the sort. He is just about a cubit in length, and in silvery brightness as attractive as a salmon.

How, then, can so small a fish, unaided by venom, inflict terrible injuries in such an incredibly short space of time? I have read somewhere that in China there used to be a torture known as the Death of the Hundred (or Thousand—it is unimportant which) Bites. It was a prolonged ordeal, purposely prolonged; but if the bites had all been delivered simultaneously with savage intensity, and a piece of flesh taken away every time, it is easy to understand that the victim would have been killed almost before he had time to realise what was happening.

Drawn by [illegible]

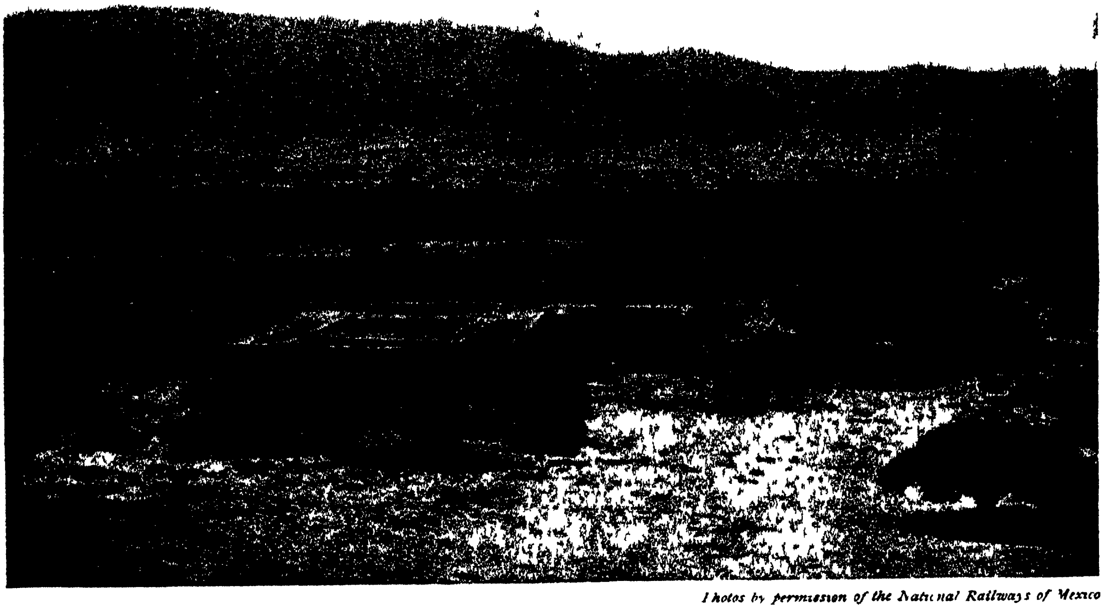
An Ox attacked by Perai when Fording a Stream

Herein lies the deadliness of the Cannibals' attack. Their jaws are inconceivably strong, and their triangular teeth are sharp as razors. Moreover, these teeth interlock, fitting each other exactly, and any substance that gets caught in this rat-trap is cut clean out—and at once.

They are children of blood, these Cannibals. Once the taint of blood gets into a pool that is cursed by their presence, thither will they swarm in their thousands to destroy. A wounded animal, whatever its power, that ventures out of its depth into their kingdom is doomed. No other fish can live in the same waters, and if a brother Cannibal comes by an injury, he does not suffer long.

Fortunately these fiends, though plentiful, have their own particular swims and keep to them. They are not disturbed by intruders, for obvious reasons. Even the alligator fights shy of them, because, if he does bring off a kill, the chances are that the Perai get about two-thirds of it whilst he is eating the remainder. If a small animal dips his nose in to drink, he is liable to have it snapped off and himself to be pulled under. A bird that sits on a bough too near the surface will be picked off in a moment.

Presumably they serve some purpose in the economy of Nature. The Perai may be the useful scavenger of the Amazons. Nevertheless, if I knew of a school of Perai I would investigate the locality with dynamite.



Photos by permission of the National Railways of Mexico

General View of Mitla as it Stands To-day

The Ruins of Mitla

The Mystery of a Vanished Civilisation to which no Clue Remains save a Few Ruins of "Edifices more worth seeing than anything else in New Spain"

By J. A. BRENDON, B.A

AMONG the world's ancient ruins few are more interesting, and none more deeply shrouded in mystery, than those at Mitla, in Mexico.

That they are of great antiquity, despite their wonderful state of preservation, there can be no doubt. Even the Aztecs were able to tell the Spanish conquerors nothing concerning them; nor have the labours of modern archæologists and antiquarians brought any definite knowledge to light. All that can be said with certainty of the ruins is that they were the work of a people who passed away at a period prior to all local traditions.

Some authorities declare that they must have stood for two thousand years at least. The historian Bancroft attributes them to the Zapotecs, who, he believes, built them at some very early stage of their civilisation. The Indians who inhabit the district at the present day are Zapotecs—a simple, primitive people, dwelling in caves and thatched hovels. Is it possible that, even after the lapse of many centuries, they could have descended so far below their former glory?

According to another theory Mitla was built by the Toltecs, who are the earliest inhabitants of Mexico of whom we have any knowledge. The Toltecs appear to have migrated into the Valley of Mexico in the seventh century—at about the time when Mohammed was spreading his religion through Asia and Africa—and to have been a people possessed of a very considerable culture.

Their sway lasted some four centuries; then, weakened by famine, pestilence, and unsuccessful wars, they disappeared almost as mysteriously as they had come. There is reason to suppose that some took up their abode in Yucatan; and it is quite conceivable, of course, that others moved into the Valley of Oaxaca, where stand the ruins of Mitla, and settled there.

The Valley of Oaxaca—the name, by the way, is pronounced Wa-hâ-ka—lies some two hundred miles south of the city of Mexico, and seems to have been a favourite dwelling of many early races, for it is covered with the ruins of former cities.

Cortez and El Dorado

The Spaniards regarded the valley as the country of El Dorado, the traditional land of gold. From the sands of the rivers which flow through it—so the Aztecs told them—came all the gold of Montezuma. Cortez believed these stories, and, with the consent of his sovereign, assumed the title of the Marquis of the Valley of Oaxaca; but, despite stratagems and subterfuges, he never discovered the sources of the legendary supply of gold.

The story is told of how, after much arguing, the Indians consented to lead one of his men to this place, if he would consent to go blindfolded. To this proposal Cortez agreed, but the Spaniard who made the journey craftily dropped a grain of corn every few paces, hoping in this way to mark the route. "After they had travelled a long distance," we are told, "the Spaniard had the bandage removed from his eyes, and he was allowed to look around, when he beheld such wealth as mortal vision never before had seen. His eyes glittered with the greed of his covetous nature, but his countenance soon changed when a dusky warrior stepped up and handed him a vessel which contained every grain of the corn that he had dropped by the way."

The Big Tree of Yule

It is in the Valley of Oaxaca, too, that stands the Big Tree of Yule, one of the largest trees in the world, a venerable relic of prehistoric days. Twenty-eight people with arms outstretched can just encircle its mammoth trunk which, six feet from the ground, has a circumference of 154 feet. Early in the last century the great traveller, Humboldt, visited the tree, and affixed to it a tablet containing an inscription and his name. That tablet is now covered with bark one foot thick.

The monster tree, in fact, is still alive and growing. Would that it could speak! Many and strange, no doubt, would be the stories it could tell. And within twenty miles of it lie the ruins of Mitla.

The earliest existing description of the ruins comes from the pen of an ancient Spanish writer who lived some four centuries ago. Yet his description might have been written yesterday, so slight has been the change wrought on the buildings by the lapse of time.

"We passed through a pueblo," he says, "which is called Mictlan, signifying 'hell' in the native tongue, where were found some edifices more worth seeing than anything else in New Spain. Among them was a temple of the demon, and the dwelling of its attendants—very sightly, particularly one hall made of something like lattice work.

"The fabric was of stone, with many figures and shapes; it had many doorways, each one built of three great stones, two at the sides and one at the top, all very thick and wide. In these quarters there was another hall containing round pillars, each one of a single piece, and so thick that two men could barely embrace

The Emissary of Cortez in the Country of El Dorado

(*Drawn by Dudley Tennant*)

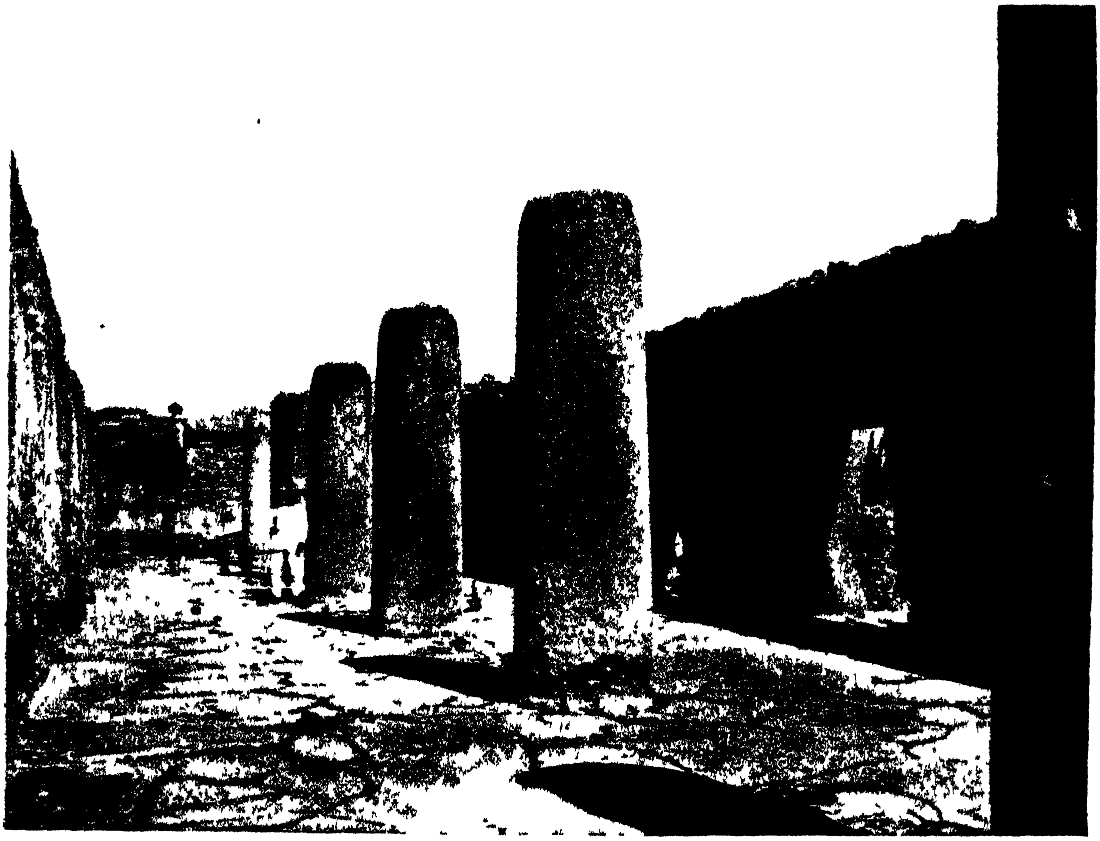
"When the Spaniard had the bandage removed from his eyes, and he was allowed to look around, he beheld such wealth as mortal vision never them;" he continues, "their height might be five fathoms."

From the name which has been given to them we can derive but little information as to the origin and purpose of these buildings. Mitla is a contraction of "Mictlan," an Aztec term signifying "death place." The Zapotecs, on the other hand, call the ruins "Lio-baa," meaning "place of delight, or rest." What, therefore, may have been the purpose which once they served, no one can tell. They may have been temples; they may have been palaces; fortresses, perhaps, or the mausoleums of kings. It is idle to conjecture.

There are five distinct groups of ruin; and the buildings they contain are of magnificent dimensions and remarkable beauty. As the photographs show clearly, they are built of carefully hewn stone.

In shape each is a square, with the sides true to the cardinal points, the front being occupied almost entirely by a wide flight of steps, at the top of which are three doorways giving access to the interior. The other walls have neither windows nor doors, and serve, therefore, to enclose a court into which open a number of chambers.

The outer walls are composed of oblong panels of mosaic, formed of pieces of stone accurately cut and fitted into the walls. The patterns are extremely intricate and hard to decipher, but they appear to be geometrical figures—a fact which tends still further to complicate the riddle of



The Hall of the Monoliths

This entire palace is a truly wonderful specimen of prehistoric architecture. The six polished columns still standing are each nearly twelve feet in height

Mitla. Elsewhere in Mexico, even in the Valley of Oaxaca, ornamentation almost invariably takes the form of human or animal figures. Why should Mitla be an exception to this rule?

The north-western court is in a much better state of preservation than any of the others. The walls here are still intact; hardly a stone is out of place; and the doorways are as wonderful as anything of the sort that can be seen even in Egypt.

The lintels are gigantic blocks of stone, 18 feet long, 5 feet high, and 4 feet thick. How they were ever got into position without the aid of machinery one cannot imagine; nor how they were hewn.

To us of to-day it is inconceivable that such huge masses could be cut from the living rock, save only by iron. Yet no iron implements have been found in, or near, any of the ruins in Mexico, and "it is certain," writes Prescott, "that the Mexicans, down to the time of the Conquest, used only copper instruments."

Passing through the doorway, one enters the famous Hall of the Monoliths, a truly wonderful specimen of prehistoric architecture. The six polished columns still standing have neither capital nor pedestal, and each measures nearly 12 feet in height. That at one time the chamber was roofed is certain, for into the tops of the pillars mortises have been cut, obviously to receive the beams of the ceiling.

From the Hall of the Monoliths one passes into a chamber of great beauty, the walls being adorned with marvellous mosaics. On either side of this chamber are four corridors, one of which is still

A Well-preserved Ruin at Mitla

To us it seems almost inconceivable that the huge masses of stone employed could have been quarried without the use of iron tools, and yet it seems that the ancient Mexicans used only copper tools in an almost perfect state of preservation. The walls are exquisitely inlaid; and so accurately were the tiles cut that mortar was neither needed nor used to keep them in place.

Below one of the buildings is a subterranean vault, built in the shape of a cross, from which fact certain enthusiasts have endeavoured to argue the existence of a pre-Columbian Christian influence in Mexico. This theory one may safely dismiss.

The underground chambers, it would seem, were probably tombs; though it is thought that they also gave access to subterranean passages, leading to—where? These passages, if ever they existed, were filled-in countless years ago, and their secrets, like all the secrets of Mitla, are safe from prying eyes.

The finest of all the ruins at Mitla lie to the north, but they have been spoiled, for right into them has been built the Christian church of San Pablo. In fact, the once beautiful court is now the "curato," and—since the priest himself does not live there—is used as a stable for pigs, cattle and horses. One of the rooms now used for this purpose contains what appear to be hieroglyphical writings, worked in lustrous red paint. These undecipherable writings are the only semblance to anything like inscriptions which have been found in the ruins.

And to anyone who would penetrate the thick shrouds of the past there is nothing more puzzling than the utter—it would seem almost deliberate—absence of clues that might help him. Even the neighbouring ruins on Monte Alban are littered with broken bits—idols of stone, figures carved in terra cotta, pottery, and ornaments. The ruins of Mitla, however, stand barren and desolate.

The men who once lived there, or the men who once prayed there, appear carefully to have removed anything that might help to trace their identity.

Principal Façade of Hall of the Monoliths

Room on North Side of Patio in Hall of the Monoliths

A Palace in the South Group, shewing Entrance to Underground Chamber

II.—In the Underworld: Natural

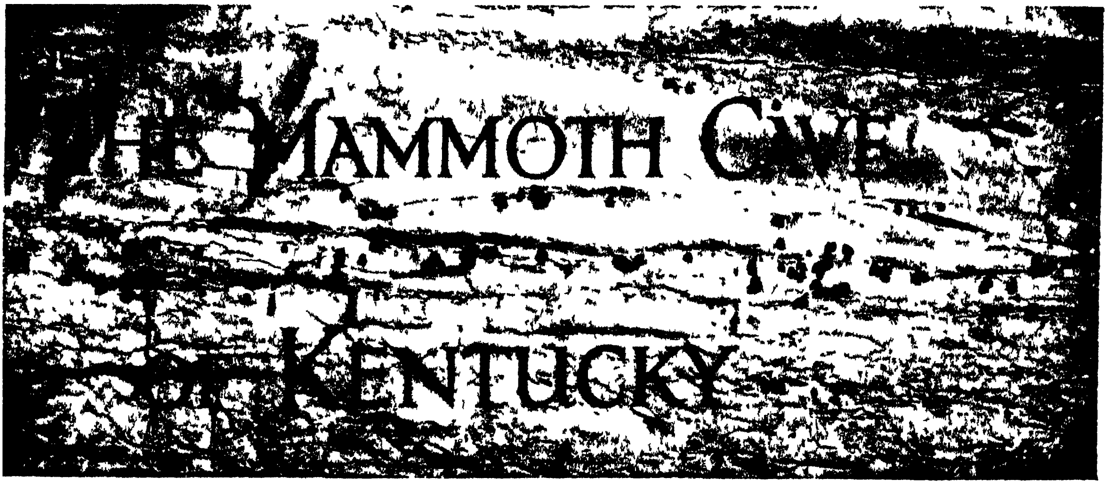


Photo Doubleday Page Syndicate, New York

The Sole Regular Inhabitants of the Cave are Bats

By ERNEST A. BAKER, M.A., D.Lit.

Author of "Moors, Crags and Caves of the High Peak," &c

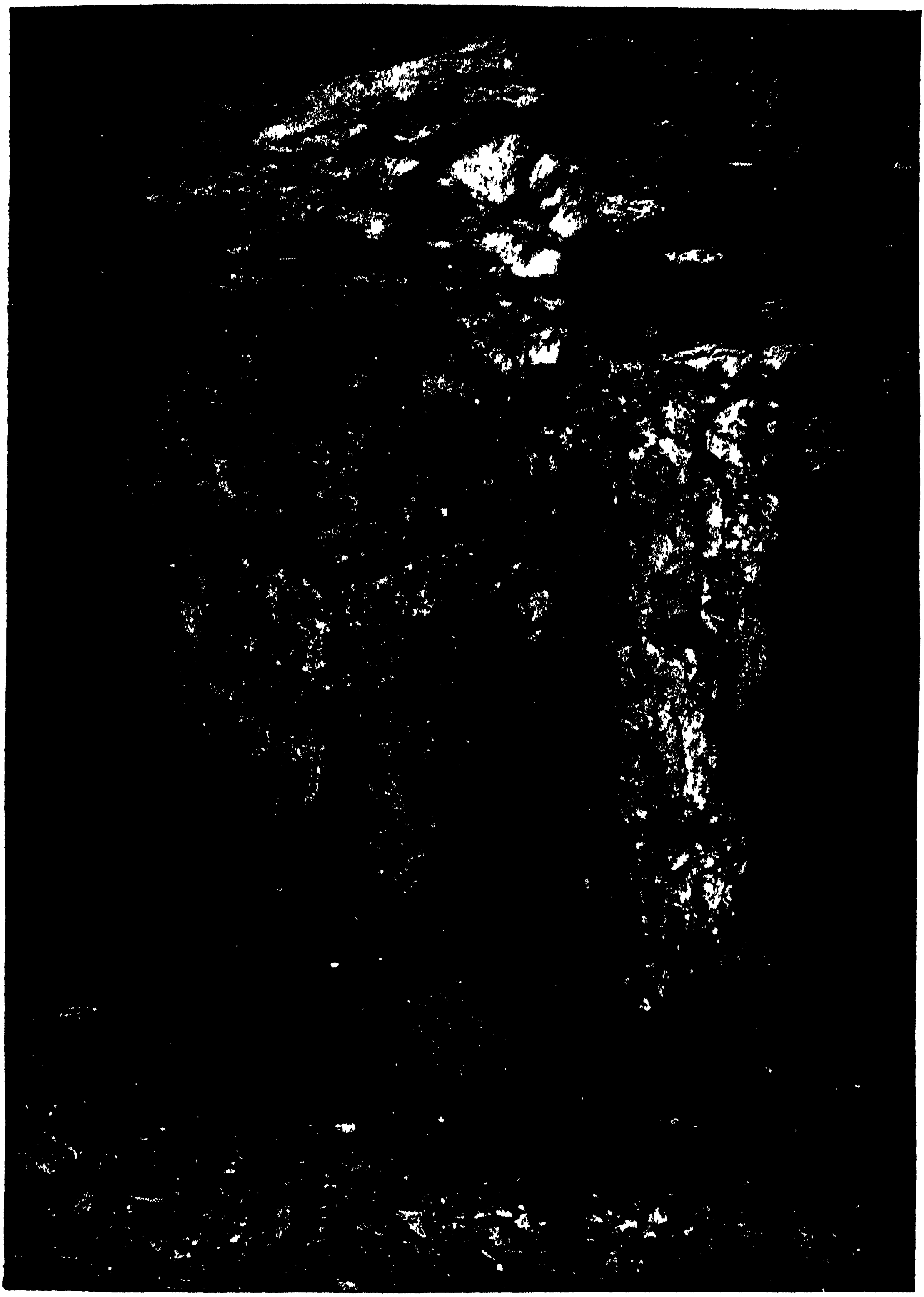
WHEREVER there is a vast extent of mountain limestone on the earth's surface we may confidently look beneath the ground for caves of proportionate dimensions.

The limestone regions of Kentucky, Indiana, and Virginia are enormous. In Kentucky alone 20,000 square miles are covered by this formation; and whilst one may travel fifty miles without catching a glimpse of running water, a legion of caverns have been discovered, comprising the two largest in the world, for the entire drainage of the country has established itself from a remote geological period in the bowels of the earth. Colossal Cavern may turn out, when fully explored, to be the biggest of these subterranean river-systems. Wyandotte Cave, in Indiana, is nine miles long; and the beautiful cave of Luray, in Virginia, though not so extensive, is still one of the marvels of the western hemisphere.

Merely to say of Mammoth Cave that it contains thirty miles of passages is to give but a faint idea of its wonders, for a few miles of travel underground are equal in toil and difficulty and also in thrilling interest to a very long journey anywhere on the surface of the globe. It is in truth an underground country rather than a cave. This huge ramification of main caverns and secondary caverns, long routes, short routes, mile-long avenues, passes, mountains, domes, rotundas, galleries, pits, lakes, dead seas, and rivers, took the earlier guides more than a lifetime to explore, and even now discoveries are made from time to time, several extensive series being opened up in 1904 and 1908.

The cave was found by accident in 1809, and at first its chief importance was due to the enormous quantities of saltpetre which it contains. The miners who began to exploit it boasted that there was store enough of nitre inside to supply the needs of the whole world. During the American War of 1812 a good deal of gunpowder was fired off, and the mining industry in the Kentucky caves was at its zenith. In the year 1814 Mammoth Cave furnished 20,000 dollars' worth of nitre for use against the British troops.

After the war, the glories of the Mammoth Cave, as an unrivalled example of subterranean scenery, began to be realised, labyrinth after labyrinth was gradually explored, impassable chasms were filled up



The Bridal Altar in the "Gothic Chapel"

The first wedding which ever took place in Mammoth Cave had a romantic origin. Having promised her mother never to marry "any man on the face of the earth," the bride avoided breaking her word—on falling in love—by being married here in the Netherworld with concrete, narrow passages were widened, rivers bridged, and many miles rendered easily accessible to any active tourist. Outside, a hotel was built, which has eventually grown into a luxurious abode in which thousands of visitors are housed yearly. Inside, marriages have been celebrated, religious services held, and sermons preached. A great number of distinguished sightseers from at home and abroad have invested the cave with all kinds of historical associations.

Mammoth Cave is not equal to the other caves mentioned in displays of stalactite. On the other hand, the profusion of dazzling crystals spangling roofs and walls, set off brilliantly by the general coating of black oxide of manganese, the snowy sulphate of magnesia covering lofty ceilings with an unearthly efflorescence, and above all the wonderful floral mimicries with which Nature has adorned many of the finest grottoes, give it a very distinctive kind of beauty. But the matchless feature of the cave is the colossal grandeur of its underground vaults, the astonishing length of its passages, many of them not only wide and lofty but strangely symmetrical, the height of the domed cavities, the size of the piers and columns, and the bigness of everything. Imagine an area of two acres spanned by a rocky vault 125 feet high! This is the chief city, where, by the way, half-burnt torches are constantly found half-buried in the floor, testifying to human occupation in prehistoric times. In the Mammoth Dome a waterfall is precipitated from a height of 250 feet, and the adjoining Egyptian Temple contains six pillars 80 feet in girth, and the same in height. Lucy's Dome is said to be 300 feet high, but in romantic impressiveness is far outdone by the Star Chamber, which is only 80 feet high, but has a roof encrusted with snowy crystals that seem to float like a cloud overhead sparkling with myriads of stars.

Flowers of Sulphate of Magnesia

The cave flowers of Marion's Avenue and Cleveland's Cabinet, two mile-long avenues, are famous. Only an American pen can do justice to these curious imitations by the gnomes of the mineral realm of the loveliest creations in the other realm of Nature. "Imagine symmetrical arches of 50 feet span, where the fancy is at once enlivened and bewildered by a mimicry of every flower that grows in the garden, forest, or prairie, from the modest daisy to the flaunting helianthus. Floral clusters, bouquets, wreaths, garlands embellish nearly every foot of the ceiling and walls; and the very soil sparkles with trodden jewels. Clumps of lilies, pale pansies, blanched tulips, drooping fuchsias, sprays of asters, spikes of tuberoses, wax-leaved magnolias—but why exhaust the botanical catalogue? The fancy finds every gem of the greenhouse and parterre in this crystalline conservatory."

It was among the columns and arches of the Gothic Chapel that the first wedding took place in Mammoth Cave. The bride had promised her mother never to marry any man on the face of the earth, and with woman's conscientiousness adhered to the letter of her vow without surrendering her inclinations. Another sanctified spot is the Methodist Church, where the miners used to worship, and where full choral services are frequently performed.

The Indian mummies which are shown to visitors came originally from neighbouring caves. They are bodies preserved by burial in the deep deposits of nitrous earth, and many have been exhumed from American caverns. The red man penetrated these silent halls and corridors many ages ago, as the incrustations of calcareous material which have gone on since clearly prove.

Some seventy years ago the cave had white inhabitants. Attracted by the uniform temperature of the cave, which never varies more than one degree winter and summer, and by the purity of the atmosphere, which is highly oxygenated, a number of consumptives took up their residence at a point a mile from the entrance. Cottages were built, of which two remain to this day, and fifteen patients made a desperate attempt to reconquer health, but with no success. Nevertheless, the exhilarating effect of the air of the cavern is remarkable; even the casual visitor notices this, and it is said that the old saltpetre miners enjoyed exuberant health.

At present, the sole regular inhabitants of the interior are a mighty host of bats—fit denizens of such surroundings.

The Consumptive's Retreat—a Mile from the Entrance

Photo by courtesy of Messrs J I Thornycroft & Co

A Destroyer Steaming 35·363 Knots on her Speed Trial

There are British "mosquito" craft of all sorts and sizes, developing horse powers from 4,000 to 30,000, and running at speeds from the leisurely 25 knots of the *River* class to the 36 or 38 of the *Swift* Inside a skin little thicker than a boiler plate is contained machinery exerting the power of a super-Dreadnought

III.—On the Sea: Artificial

Photo by courtesy of Messrs. J. I. Thornycroft & Co.

The Boiling Mound of Foaming Sea Astern

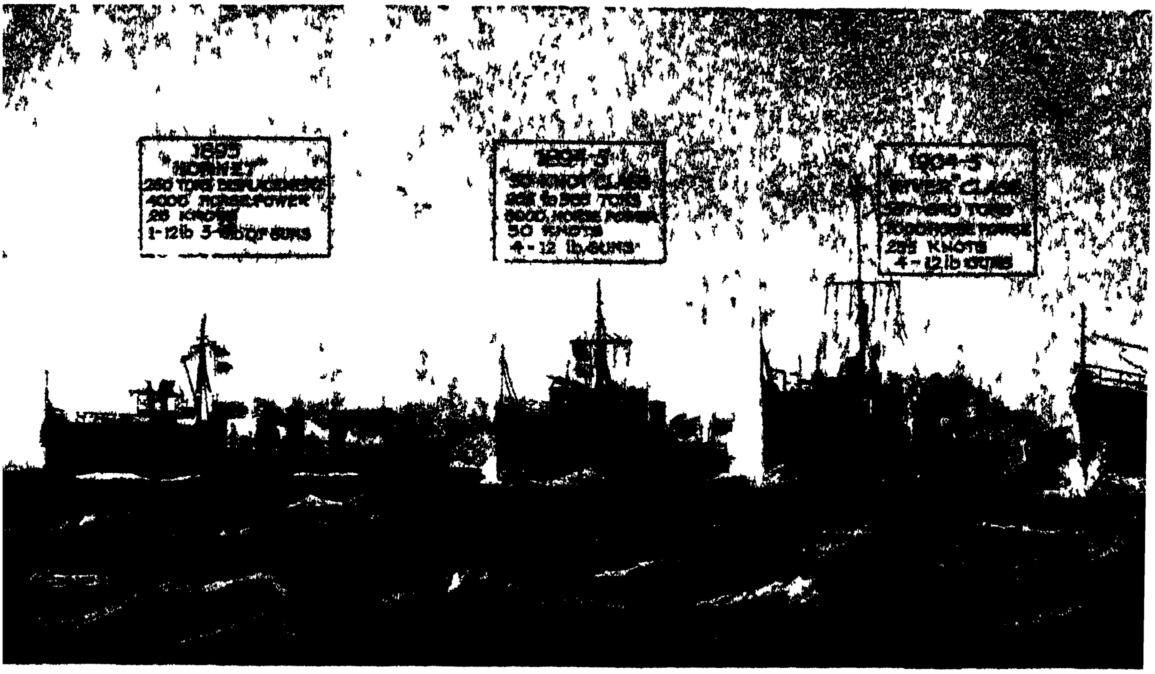
The Fleetest of the Fleet

The Wonderful World of the Destroyer

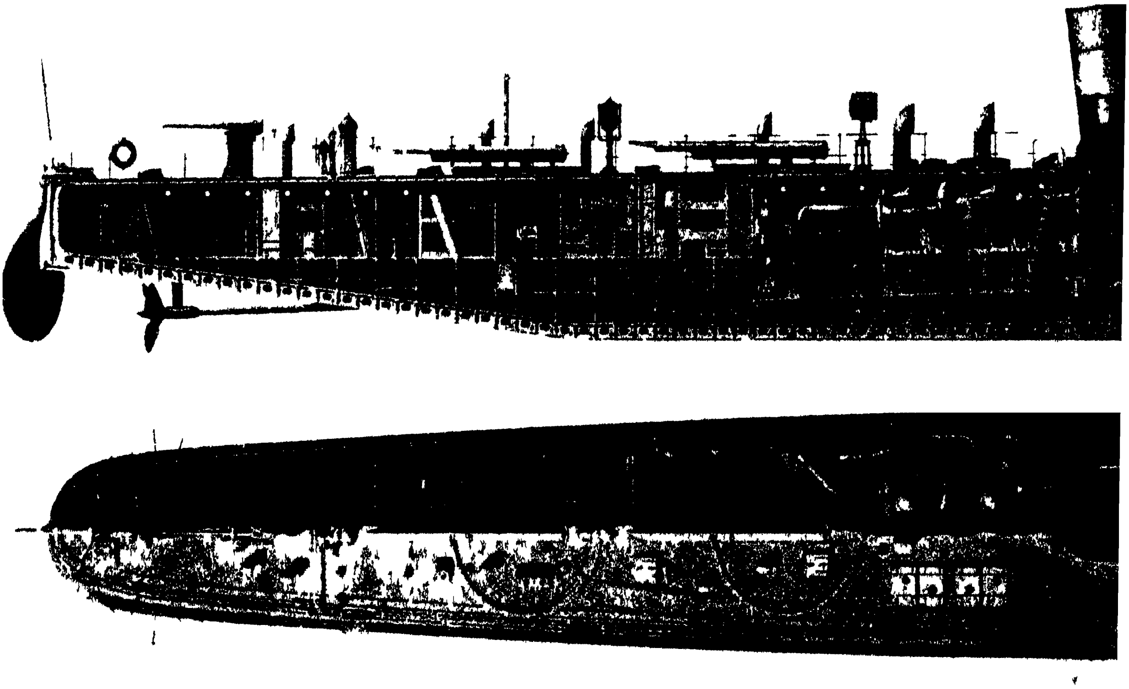
By HORACE C. DAVIS

TWENTY years ago the class of vessel known as the "Destroyer" came into being, primarily to hunt down the enemies' torpedo boats, and, as the name implies, destroy them. To-day the destroyers have become the torpedo boats, and chiefly their work is to attack the big ship under cover of the gusty night, or act as the Admiral's eyes and ears, darting ahead to see the position of the foe, seeking out for hostile torpedo craft, and "wirelessing" all the news back to the flagship. Maybe the Admiral will require their services to form an effective screen round the precious battleships by night when steaming at sea, and thus the destroyer has grown so large that it can accompany the fleet in any weather. It has been given the 12-pounder as well as the 4-inch quick-firing gun, and, thus armed, it can fight others of its kind, and, if necessary, pump shells into the unwary submarine that shows itself incautiously.

To-day Britain's modern boats have a displacement ranging round 1,000 tons, and the speed has reached 40 miles an hour. Twenty years ago, or so, the destroyer was of 260 tons and the speed but 25 knots. Great Britain now possesses "mosquito" craft, of all sorts and sizes, developing



THE DESTROYER HAS INCREASED VERY RAPIDLY



ITALIAN TORPEDO BOAT DESTROY

LARGE NUMBERS OF CRAFT BUILT BY NAVAL POWERS DURING THE GREAT WAR.
NEAR FUTURE 5000 TONS HORSE POW KNOTS GUNS

Drawn by G. H. Davis

IN TWENTY YEARS—WHAT WILL ITS FUTURE BE?

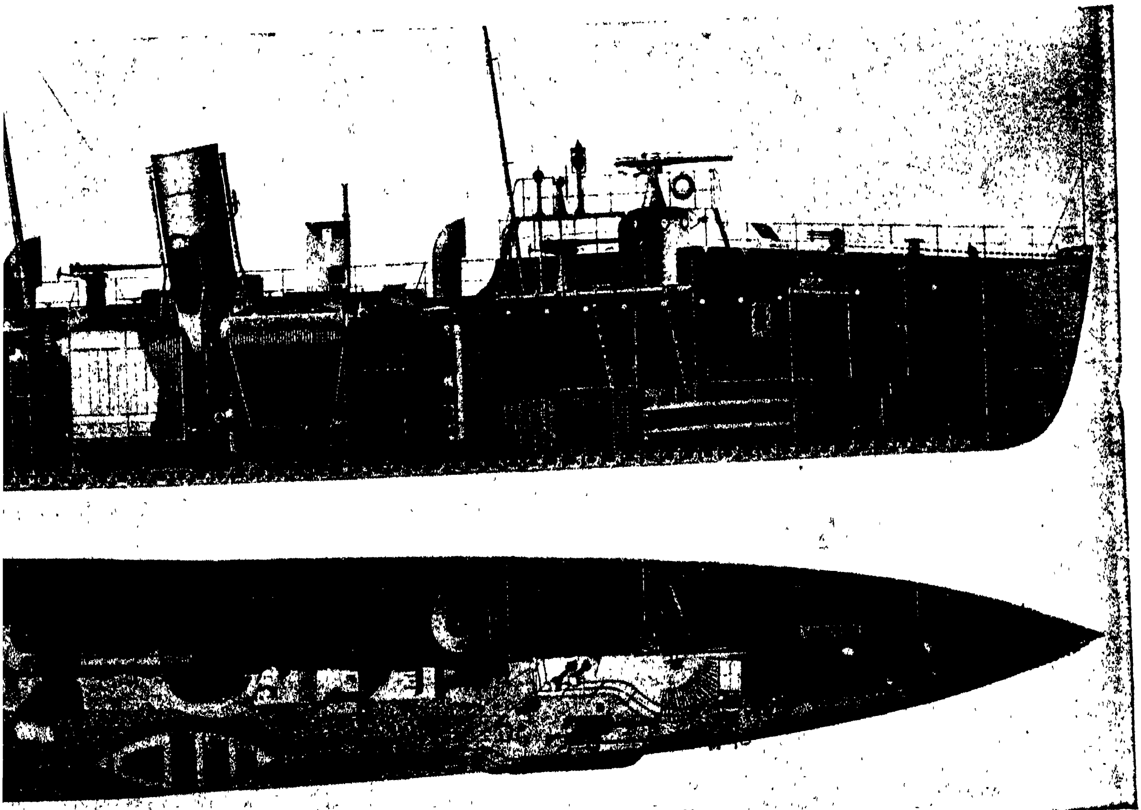


Photo by courtesy of Messrs. J. I. Thornycroft & Co.

THE "NEMBO" CLASS, IN SECTION

horse-powers of from 4,000 to 30,000, and running at speeds from the leisurely 25 knots of the *River* class to the 36 or 38 of the *Swift*. Inside a skin little thicker than a boiler-plate is contained machinery exerting the power of a super-Dreadnought, and boilers that are one complicated mass of tubes, and with turbines that are one of the greatest engineering marvels of our time.

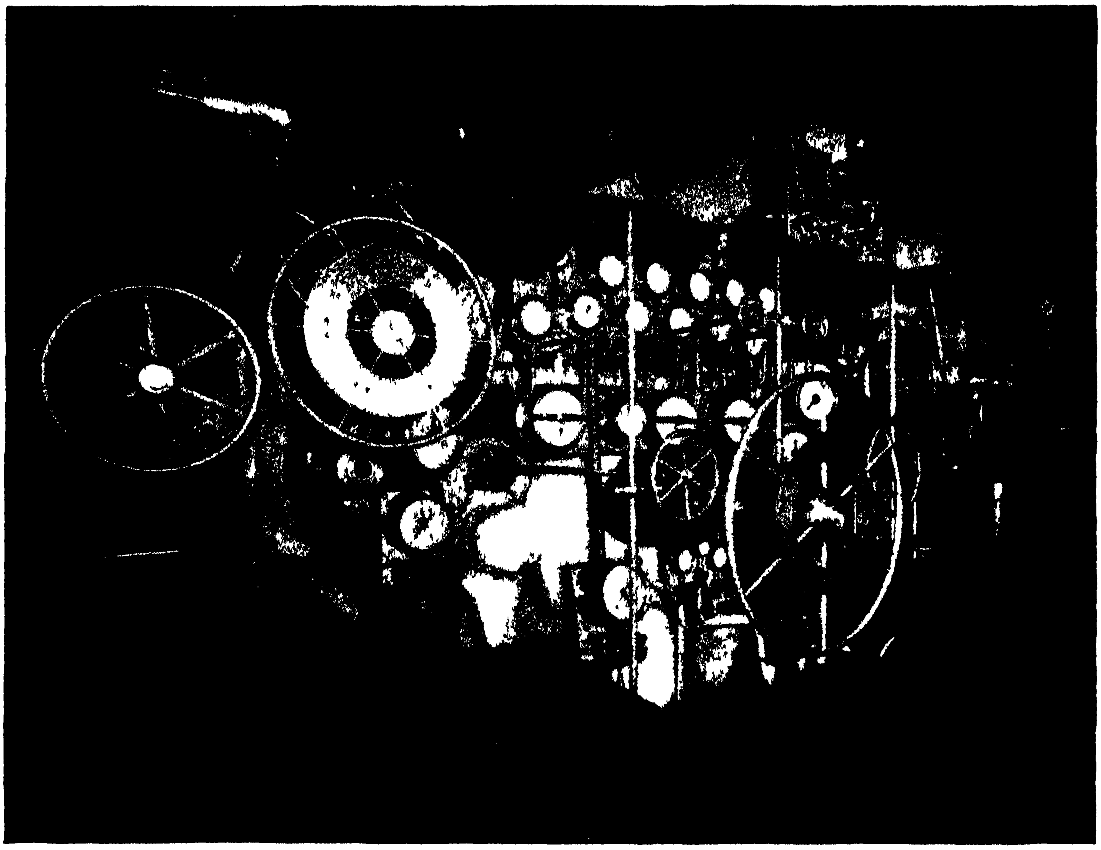


Photo by courtesy of Messrs. J. I. Thornycroft & Co.

The Engine-room of a Torpedo Boat Destroyer

The engine-room is a mass of mains and dials, gleaming wheels and glistening levers

The torpedo craft of the world as the Great War has demonstrated—are the home of *men*. They are no place for the middle-aged. They are the rough school of actual experience, wherein are trained the young dare-devils who in later years are to handle the heavy metal of the fleets.

In the British Navy the Lieutenant-Commander, still in his twenties, has to handle a box of mechanical power, that rolls villainously in heavy weather, that smothers herself in foam at the slightest provocation, and is a domain of steel and copper, naked and gleaming; a craft that has been built to drive pell-mell through the riven seas and play all sorts of strange antics with other sombre-hued friends in the midst of the hurrying traffic of the Channel or around the scared and cursing fishermen of the North Sea. Quite well the clean-shaven young gentlemen, who command these destroyers, know that a "Bumping-match"—which is their slang for a collision—caused perhaps by a momentary lapse on a cold and bustling night, when the spindrift is driving over the bridge in cutting sheets, will probably mean a court-

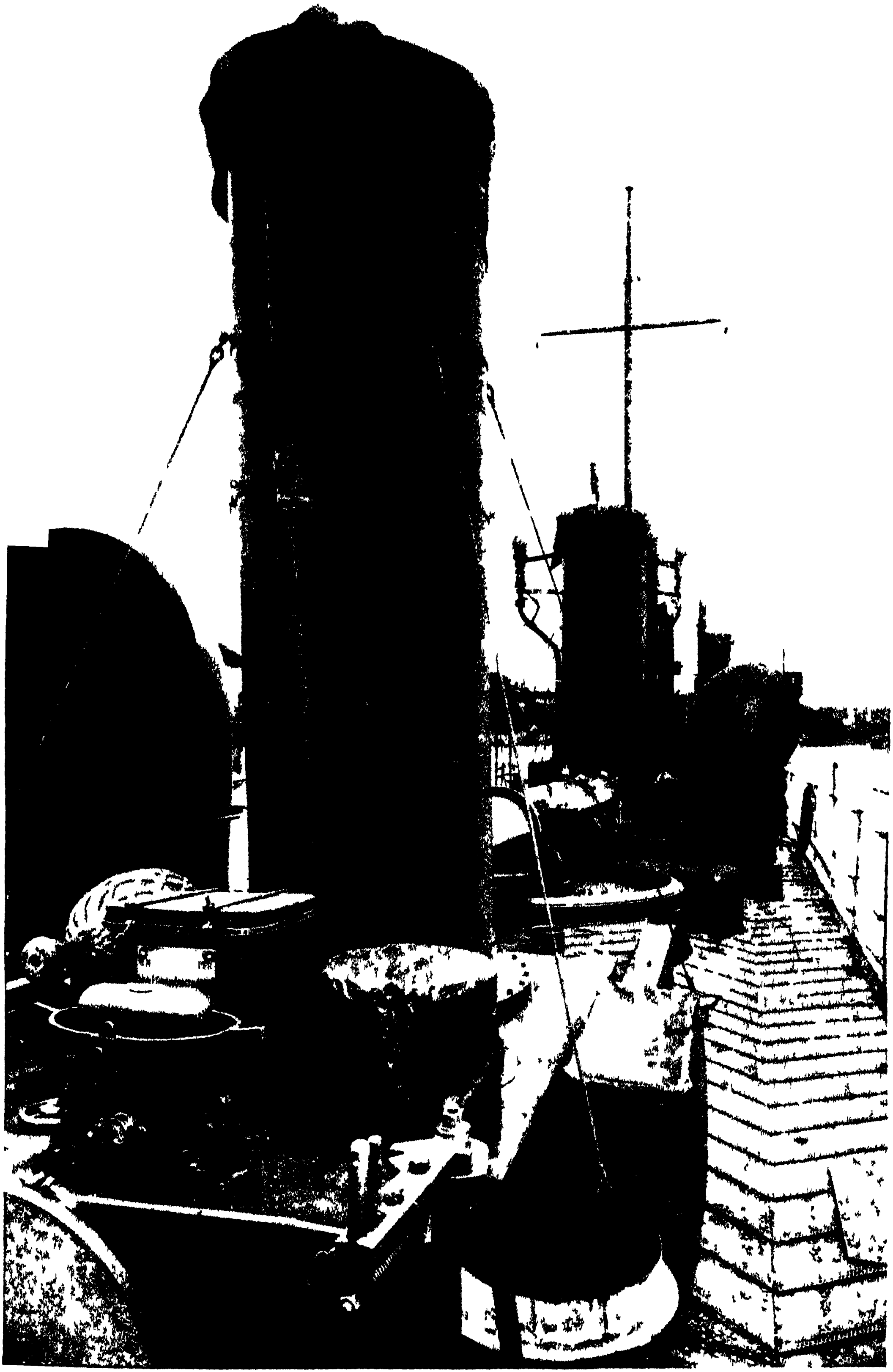


Photo by courtesy of Messrs J I Thornycroft & Co

Looking towards the Bows

Between the funnels is the torpedo tube and its turntable martial and their sudden exit from the Service. Yet, nevertheless, they are expected to learn their profession thoroughly, and it is part of the game to drive at the rate of an express train through foul and gusty weather, with grim, hurrying clouds overhead and great shouldering waves as their companions, while they play at evolutions, guided by the winking lantern on the stern post of the "next ahead" that ever and anon will be drawing away and coming towards them as the speed alters.

The Stokeholds

Take a trip below. Visit one of the stokeholds; in front are the glaring eyes of the furnaces; in the centre are the pumps forcing the oil through the burners into the firebrick lining of the boiler and there becoming one great white incandescent mass of intense heat. On either hand roar the huge fans pumping air below to feed the flames with oxygen. Scintillating in the light of the wire-protected electric lamps are the gleaming mains, some bare copper, others asbestos covered. The wheels of valves stick out here and there, and to control this world of concentrated power are a few stokers, who steadily and keenly keep a knowing eye on these devices.

Before the advent of oil fuel this den would be an inferno of heat and sweating human beings hard at work with shovel and clinker bar. To-day, with the coming of oil fuel, the stokehold of a destroyer is calm, and, owing to the air required for the furnaces, comparatively cool.

Having negotiated yet another perpendicular ladder, you come to a place where the heat is tropical, where, hidden and latent, showing no outward movement except for the quivering hands on the gauge glasses, are the turbines. Inside the casings the rotors, catching the steam on their thousands of knife-edged blades, are whirling the shafts at hundreds of revolutions per second.

The destroyer's engine-room is indeed a wonderful place; it is a domain where work those men who drive their fragile ship ahead at a speed that appears madness to all the other skippers of the sea—men who are blind to all that happens outside their steel-walled pen, and who have to place their confidence in those muffled figures stamping their frozen feet on the bridge.

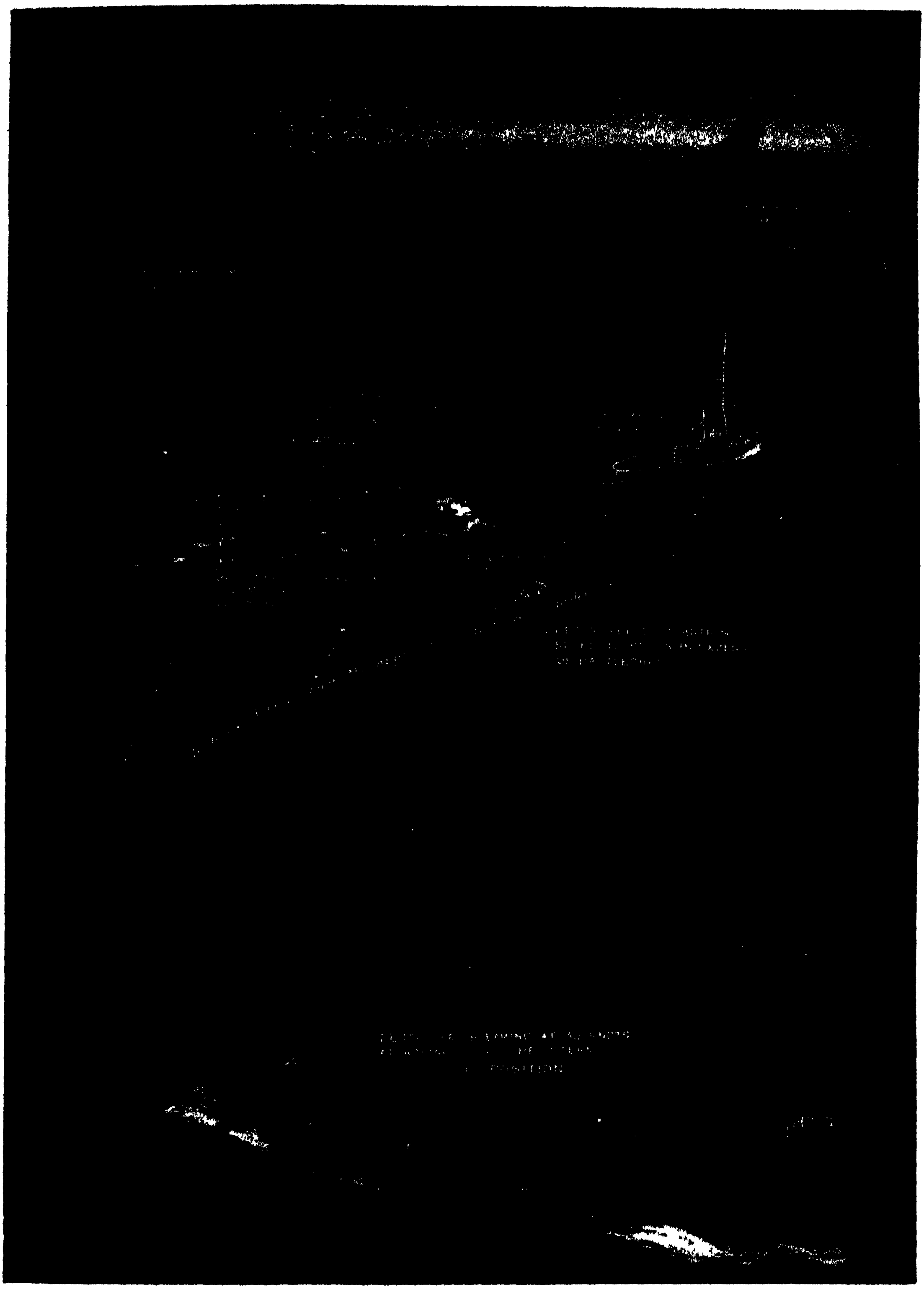
The space, naturally small compared with the horse-power generated, is a mass of mains and dials, gleaming wheels, and glistening levers. Every main is working under three and four hundred pounds pressure to the square inch, and a burst means disaster, sudden and sure.

Clamber from here and pass aft, and observe the torpedo tubes. Each is able to discharge the 21-inch torpedo—one of the deadliest projectiles in the world. There the whole deck is occupied by necessary gear. Four boats, lashed tight to their curved davits, may any moment stand between 100 men and death.

Officers' Quarters

Down more steps and enter the tiny wardroom with its cloth-covered table, its navigating instruments, and general air of cosiness. From here pass to where the commissioned officers sleep in their neatly curtained bunks, with telephones and speaking tubes close beside them, so that even if the sleeper has turned in for his "spell below" he is liable to be hurried out at any hour of day or night. Right in the bows live the crew, cramped, cabined, and confined, with their lockers and swinging hammocks for beds. The naked steel plates of the vessel act as bedroom walls, and the fierce beat of the driving seas smashing over the bows as a lullaby.

This is, then, the world of the torpedo craft, that play so important a part in the warfare of to-day and to-morrow. To concentrate so much power, to crowd so many hundreds of complicated pieces of mechanism inside so small and frail a ship, is, indeed, an engineering wonder.



The Strategy of Destroyer Attack—why she Attacks from Ahead

(Drawn by G. H. Davis)

A destroyer attacks a battleship from the bow for the reason that (as shown at the top of diagram) the two may be passing at 50 knots an hour, and the destroyer can discharge her torpedoes and get out of range before the surprised gunners in the big ship have time to fire at her. If she attacked from the stern (as shown at bottom) she would be exposed to danger much longer

The Great Modern Explorers

Concerning the Pioneers of the Nineteenth and Twentieth Centuries who have Mapped the Globe

By SIR H. H. JOHNSTON, G.C.M.G., K.C.B.

AT the beginning of the Anti-Slave Trade agitation in 1785, and thirty years later, when the Napoleonic wars came to a close, our utter ignorance of interior Africa was a source of anxiety to philosophers and statesmen in England and Scotland, in France and Portugal.

The Portuguese in 1798 had dispatched Dr. Lacerda to attempt a crossing of Central Africa between Mozambique and Angola, and although he only got half-way he indicated some important features in Central African geography, though his work was not properly understood until the opening years of the nineteenth century.

African Pioneers

In 1808 the British Government dispatched Mungo Park to finish his exploration of the Niger, a feat he accomplished as far as the rapids of Busa, where he perished. In 1816, Captain Tuckey was sent out to find if the mysterious Congo was really the mouth of the equally mysterious Niger. He died before he could penetrate farther inland than Isangila. In 1822-7 the British Government carried out the complete survey of the whole African coast, a gigantic feat of discovery and map-making which was carried out mainly under the admirable supervision of Admiral Sir William Owen.

The British occupation of Malta led to intercourse with Tripoli, and that in turn to inquiry as to the mysterious Lake Chad and the course of the Niger to the south of the Sahara Desert, and subsequently to the dispatch of exploring expeditions in 1818 and 1822 (under Ritchie, Lyon, Oudney, Clapperton, and Denham) which led to the discovery of Lake Chad, and ultimately through Clapperton and Richard Landor to the tracing of the Niger down to its delta.

The ascent of the Niger by an expedition in 1832 under Macgregor Laird effected the discovery of the Benue, its great eastern tributary.

Mystery of the Nile

Between 1851 and 1855 all these discoveries were amplified and connected by the Trans-Saharan expedition of Richardson, Barth, and Overweg. A British traveller named William Browne had already reached Darfur by an overland journey in 1793. The Egyptian campaigns against Napoleon Bonaparte further stimulated interest in the mystery of the Nile. This exploration was at first taken up by Germans and Frenchmen in connection with the government of Muhammad Ali, the great-grandfather of the present Sultan of Egypt. In the course of these steamer explorations of the White Nile, European knowledge was carried as far south as the vicinity of Gondokoro, where it was stopped by the first cataracts in that direction and also for some distance up the many western tributaries of the Bahr-al-Ghazal.

During the first half of the nineteenth century, moreover, Abyssinian geography, and the geography of Madagascar were being revealed by British missionaries. Meantime great progress was being made in regard to the opening up of South Africa. Robert Moffat and other missionaries had crossed the Orange River and entered Namakwaland, had penetrated even to the verge of Damaraland, had crossed the

Limpopo and found themselves in what is now Southern Rhodesia.

Their missionary comrade, David Livingstone, shot far ahead of the others, especially in companionship with W. C. Oswell, a shooter of big-game and retired Indian Civil Servant. Oswell and Livingstone discovered Lake Ngami in 1849, and the Zambezi in the heart of South-central Africa in 1851. Thenceforth Livingstone carried on the exploration by himself, and between 1852 and 1856 had traced the Zambezi almost to its source, had discovered the upper Kasai and Lulua rivers, and passed westwards to the Angola coast, thence retracing his steps to descend the Zambezi to its delta.

Two years afterwards he returned with (Sir) John Kirk and discovered Lake Nyasa. In 1866 he crossed from the Zanzibar coast to Lake Nyasa, and passed by way of the upper Luangwa valley to the south of Lake Tanganyika from there reaching Lakes Mwera and Bangweulu. Concurrently with this he discovered the upper course of the rivers Luapula and Lualaba—in fact, the upper Congo, which he traced northward as far as Nyangwe. Returning to Bangweulu he died there in 1873.

The Nile mystery had been finally solved firstly by the dispatch of an expedition under Captain (Sir) Richard Burton and John Hanning Speke, which revealed Lake Tanganyika and the Victoria Nyanza, and many other facts in East African geography.

Speke returned with a companion, J. A. Grant, in 1860, continued his discoveries of the Victoria Nyanza, found its outlet in the Victoria Nile, traced that stream northwards until he fitted in his own journeys with those of Sir Samuel Baker, who had discovered the Albert Nyanza, and of Samuel Petherick, who had revealed much of the geography of the Bahr-al-Ghazal. The work of Nile exploration was later carried triumphantly to the Congo basin and the River Wele by Dr. George Schweinfurth.

Livingstone at a crisis in his fate had been relieved and given two more years of life by the expedition under Henry Morton Stanley; and Stanley returned to Africa soon after Livingstone's death, completed Speke's outline of the Victoria Nyanza Lake, discovered what is now called Lake Edward, and reached the Upper Congo, where Livingstone and Cameron had left it at Nyangwe.

Drawn by Ernest Prater

David Livingstone in Africa

In spite of sickness this great and indomitable missionary explorer pushed on with his work of discovery

Commander V. L. Cameron had arrived earlier on the scene to complete Livingstone's discoveries, had made a more or less accurate map of Tanganyika, but had felt unable to pursue the course of the upper Congo beyond Nyangwe owing to the difficulties which lay in his path. As an alternative he crossed Central Africa by a Portuguese route to S uthern Angola.

Stanley, however, was made of somewhat sterner stuff and perhaps had a better equipped expedition, and was on better terms with the great Arab pioneer, Tiputipu. With Tiputipu's assistance he struggled past the exhausting barrier of the Stanley Falls till he reached the navigable river itself at its great northern bend. Here, getting into canoes, he rapidly descended the upper Congo till he reached what is now known as Stanley Pool, only a little over 300 miles from the Atlantic coast. In another long string of rapids and cataracts between Stanley Pool and the estuarine Congo, his difficulties were enormous, and he emerged from them, the sole White man of the expedition, prematurely aged and white-haired, though still in early middle age.

Livingstone Stanley, and Grenfell

After a brief rest he returned to reorganise the basin of the Congo as a civilised State, and finally led an expedition from the west to relieve Emin Pasha of the Sudan. In the course of this expedition he put the completing touches to the great discoveries of Africa, for he revealed the remarkable characteristics of the north-east waterparting between the systems of the Congo and the Nile and the great snow mountains of Ruwenzori. (The still loftier snow-capped volcanoes of East Equatorial Africa—Kilimanjaro and Kenya—had previously been discovered and explored by the missionaries Krapf and Rebmann, by Baron von der Decken, Joseph Thomson, and the present writer.)

But although it was Stanley who laid down the main course of the great Congo, from where Livingstone had left off to its outlet into the Atlantic, there still remained almost equally important work to be done in tracing its enormously long affluents both north and south. The immense Kasai, discovered at its source by Livingstone, was placed on the map by the German traveller von Wissmann, and its important affluents, the Sankuru, Lulua, and Kwango, by other German travellers (for the most part).

The Congo System

Perhaps a greater Congo explorer even than these last was George Grenfell, the Baptist missionary, who discovered in its western half the great Mabangi affluent of the Congo, which was none other in its upper course than the Wele revealed by Schweinfurth. To Grenfell we owe more than to any other pioneer the revelation of all the other great rivers of he Congo system except the Sanga, which was described by Paul Crampel, a Frenchman, who, together with de Brazza and other explorers of French nationality, had revealed the geography of the north-west basin of the Congo and of the Ogowe system.

One of the blankest parts of Africa, however, down to the closing years of the nineteenth century was Western Nigeria, virtually all the region behind the forest belt of the west coast and even within that forest belt, and the chief pioneer in this direction was Colonel Louis Binger, who explored the far extending basins of the Black and White Volta and laid down all the main facts in West Nigerian geography.

Other Frenchmen have by degrees, especially in the opening years of the twentieth century, revealed almost all there is to be known in regard to plateaus, mountains, extinct volcanoes, dry river courses, dried up lakes, and Neolithic rock engravings throughout the vast Sahara Desert. The Italians have been very active in North-east Africa, Galaland and Abyssinia. That region of Africa which is still least known —the Libyan Desert—has been explored of late by W. Harding King.

In South Africa amongst the great pioneers of the nineteenth century was Frederick Chapman, who was contemporaneous with Livingstone, but who carried on throughout the 'sixties most valuable exploration of the region called German South-west Africa, a region revealed to the world almost entirely by the British and by a half-British explorer, Andersson the Swede. Thomas Baines travelled both with Chapman and Livingstone, and independently. Karl Mauch first definitely discovered the amazing ruins of Zimbabwe—still an unsolved mystery. Major Gibbons greatly added to our knowledge of north-west Zambezia, and Sir Alfred Sharpe revealed several new and interesting facts regarding the rivers and lakes of the eastern parts of Northern Rhodesia. The present writer also explored that region and discovered with Dr. Cross the south end of Lake Rukwa.

South African Pioneers

Two other pioneers of East and Central African discovery who should be mentioned, are Captain Hoare and Mr. J. E. S. Moore, who drew attention to the seemingly marine fauna of Lake Tanganyika, and Mr. C. W. Hobley, who proved that these water creatures—shrimps and jelly-fish and suchlike—were not peculiar to Tanganyika or necessarily marine in their origin, but were also found in Lake Victoria. It was Mr. Hobley who, besides revealing new languages and new peoples, drew attention to the remarkable fossils in the countries verging on the eastern shores of the Victoria Nyanza.

It is in this direction that the African discovery of the future will mainly consist, that of the resources in wealth of minerals and vegetables.

The opening of the twentieth century has witnessed the final clearing up of other blank spaces in the map outside Africa; the splendid expeditions led by Captain Scott, by Amundsen, by Sir Edward Mawson, and Sir E. Shackleton, have at last placed the Antarctic continent with some definiteness on the map, and have revealed to us its ranges and plateaus of extremely lofty mountains, its awful ice caps and its fossil vegetation.

Twentieth-century Discoverers

The snow mountains of New Guinea have been scaled, their altitudes measured, and their fauna collected, by British and Dutch explorers. Almost the highest, if not the highest, peaks of the Andes and Himalaya have been climbed by women as well as men, of English, American, German, or Italian nationality. Lt.-Colonel Godwin Austen was the leading nineteenth-century pioneer in this direction and the virtual discoverer of Mount Everest, the highest mountain on the earth's surface.

The Duke of the Abruzzi—one of several noteworthy Italian explorers of Central Asia—has ascended and measured all the snow peaks of the Ruwenzori range in Equatorial Africa. The North Pole—a point of latitude and longtitude in the middle of the frozen ocean—has been reached by the American Peary, just as the South Pole has been by Amundsen and Scott. Colonel Roosevelt and Brazilian officers have probably found the last river of any size which can be revealed in the geography of Brazil.

The Threshold of Discovery

There are no more islands to be found in the Pacific Ocean, probably no more high mountains exist which have not been placed on the map, there are no big lakes to be revealed, even if a great many large and small ones are as yet imperfectly delineated. All the main facts of geography are now before us.

But we are only on the threshold of discovery, for still locked in the rocks, buried in the sands, moulded in the mud, concealed by the forest, covered by the ocean, yet discoverable by the resources Man now possesses, are the fossil remains which should reveal to us not only the history of the development of life on the earth's surface, but what is most interesting of all, the whole course of Man's evolution.

Helium

A Wonderful Story of Modern Discovery

By ARTHUR HOLMES, F.G.S., A.R.C.S.

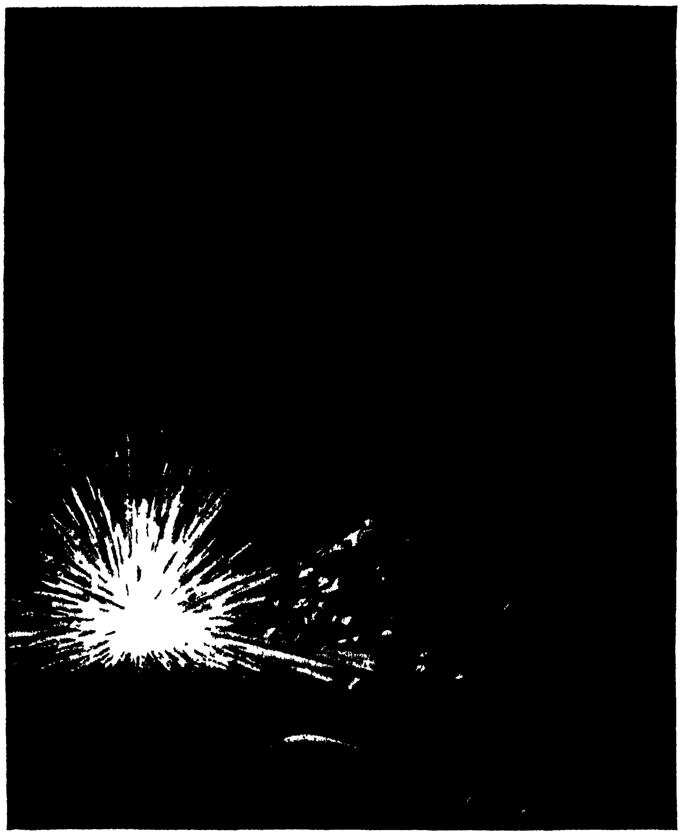
Author of "The Age of the Earth"

On August 18th, 1868, there was a total eclipse of the sun, and as it could be seen to the best advantage in the East, a number of European scientists were sent out to investigate the solar phenomena. All the observers were intent on examining the chromosphere, and the prominences that are projected from its agitated surface. Except when the moon cuts off the full blaze of sunlight, these interesting and hitherto obscure objects could not be seen, and on this occasion they were to be examined for the first time with the aid of the spectroscope.

The spectroscope is an optical instrument by which the most complex beam of light may be analysed into its simplest components. The most primitive form of spectroscope is a glass prism which, when sunlight falls upon it, splits up the white beams into a coloured band. In the same way the rainbow is born in the recesses of innumerable falling raindrops.

When the light of the chromosphere was analysed, it was proved at once, from the fact that its spectrum was made up of a large number of bright lines, to have been emitted by a mass of glowing luminous gases. Now, not only can the modern astronomer decide whether or not he is dealing with a gaseous body, he can also determine its chemical nature, for each element gives a number of lines whose position in the spectrum can be readily determined. During the 1868 eclipse nine lines were identified, and it was thought that the chromosphere contained both hydrogen and sodium.

The French astronomer, Janssen, was so impressed by the brilliancy of the lines, that he felt sure they could be seen again in broad daylight. The next day he turned his spectroscope to the part of the sun which he considered most



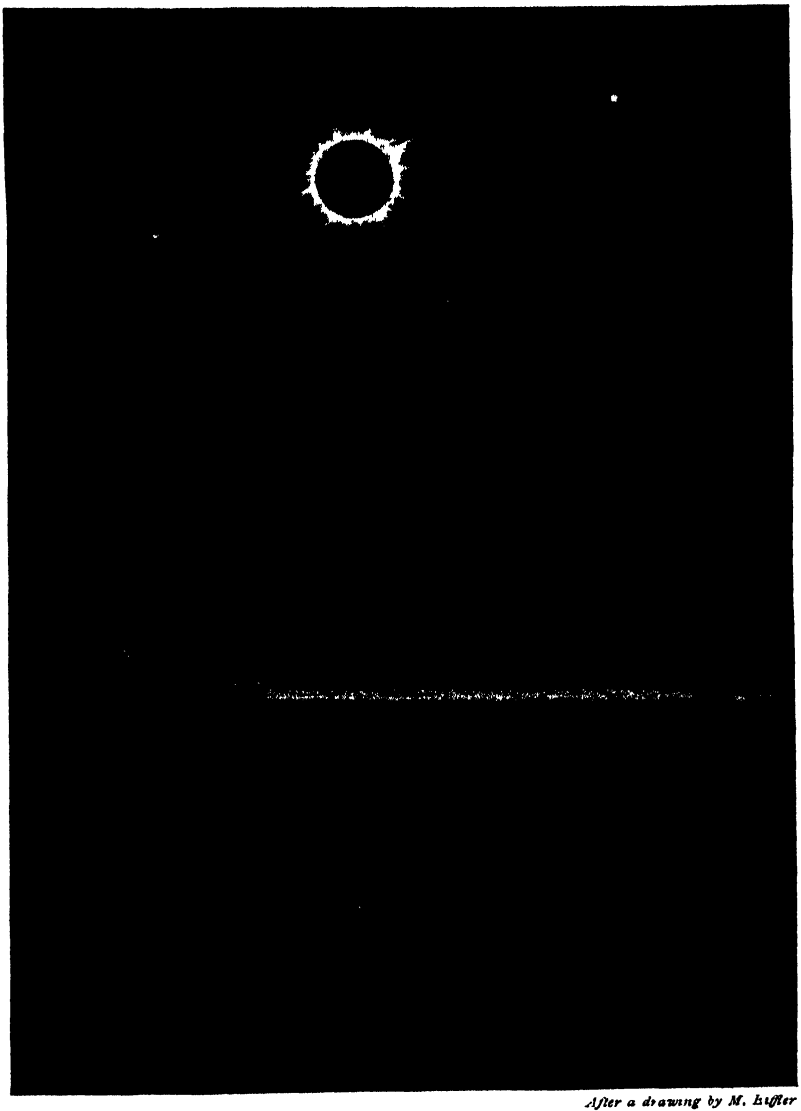
In one year 1 oz. of radium, in liberating helium, gives out as much heat as could be obtained by burning 20 lb. of coal

favourable, and sure enough the lines he had seen during the eclipse shone out again. He was now no longer hurried, and examining the lines at leisure, he found, to his surprise, that the bright yellow line which had been taken for that of sodium was not quite coincident with the sodium line. Evidently a new element, not previously known, was represented by this yellow light wave from the glowing gases of the sun's outer atmosphere.

Janssen remained for several days at Guntoor, in Eastern India, where he was situated, applying his new methods of solar research. As he was farther from Europe than the other observers, his report of the eclipse, delayed both by the discoveries he had made and by the length of the journey, was the last to arrive. Meanwhile, Sir Norman Lockyer, who was not a member of any of the eclipse expeditions, had independently discovered that the spectrum of the chromosphere could be seen in full sunlight, and thus, being able to examine it just as Janssen had done, he found the same yellow line almost, but not quite, in the position for sodium. Lockyer wrote a letter to the French Academy of Sciences announcing his discovery, and by a curious coincidence the letter arrived by the same post as Janssen's report. Both communications were read at the ensuing meeting of the society, and in honour of the two astronomers, the French Government struck a gold medal bearing their united likenesses.

The new element received the name Helium, to witness the fact that it was found in the sun while as yet it was unknown as a terrestrial element. Indeed, twenty-seven years had to elapse before it was re-discovered on the earth.

In 1893, Lord Rayleigh found that chemically prepared nitrogen was somewhat lighter than the nitrogen of the atmosphere. The difference was not very



After a drawing by M. Löffler

Total Eclipse of the Sun

great, but so delicate was the balance which Lord Rayleigh employed, that had the difference been fifty times less it could still have been detected. The anomaly called for an explanation, but for some time none was forthcoming. Sir William Ramsay, however, took up the question in 1895, and, as a result, discovered no fewer than five new elements in the atmosphere. He passed the atmospheric nitrogen over a red-hot mixture of magnesium and lime. This absorbed nitrogen alone, and a heavier gaseous residue remained. The spectroscope revealed a great number of new lines in the light emitted by the newly-separated gases, and among them was helium, which, although still unseparated, was now recognised in a laboratory for the first time.

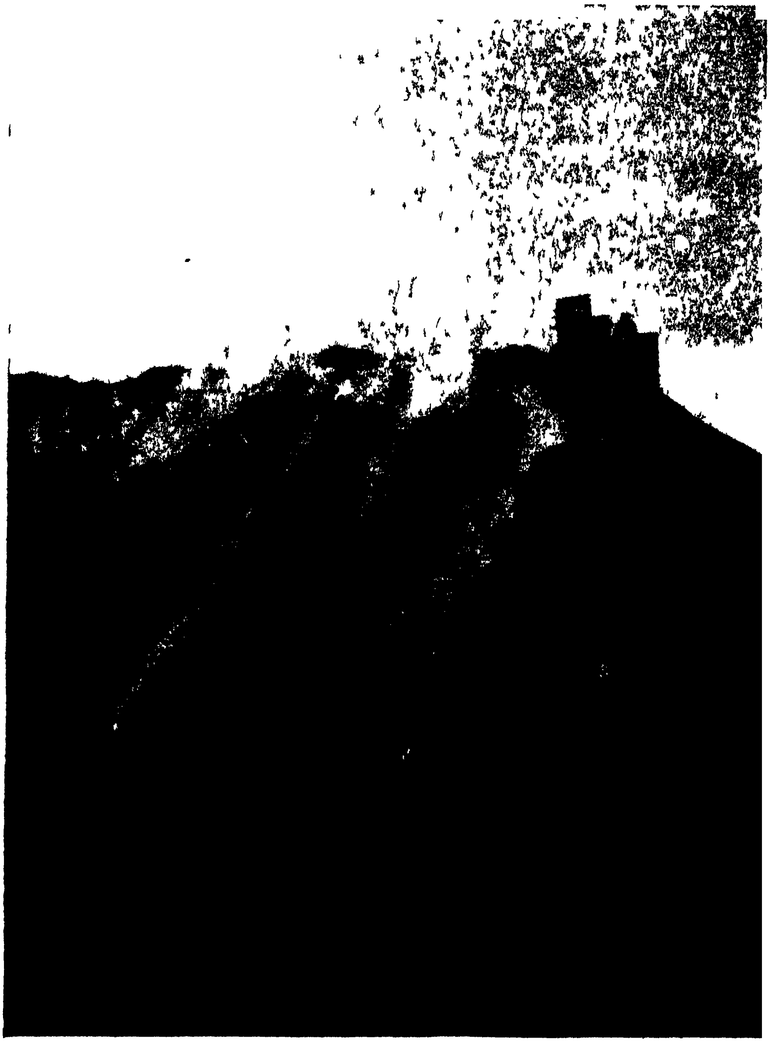


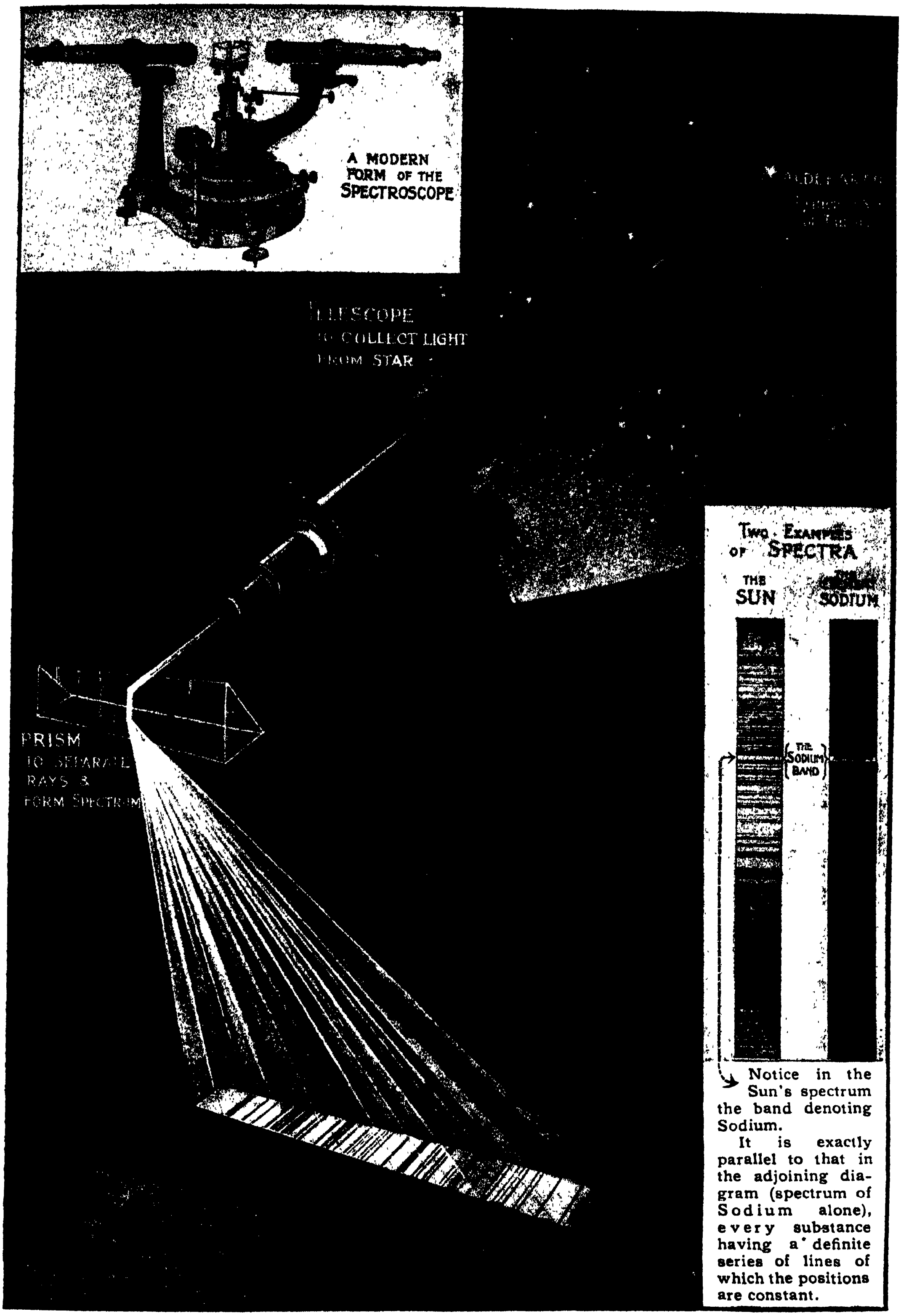
Photo Alfredo & Agostino Naples

The New Crater at Vesuvius in Eruption

Helium has been detected in the gases ejected by certain volcanoes

When these newly-discovered gases of the atmosphere were cooled in liquid air, part of the mixture liquefied, but the remaining part continued to exist in the gaseous state even at the low temperature of 185° C. below zero. By careful distillation, the liquid part was ultimately divided into Argon, which boiled off first, and Krypton and Xenon, which evaporated at a later stage. To separate the constituents of the gaseous portion, liquid hydrogen at a temperature of 240° C. below zero was used. Part of the mixture was frozen, part still remained as gas. The former was called Neon, and the latter, the only one of the atmospheric gases which remains a gas at this appallingly low temperature, proved to be helium. In this way, the first pure helium which was ever collected was prepared.

Some idea of the low temperature at which it was necessary to work may be grasped from the fact that, when the liquid hydrogen bulb was removed from the apparatus, a ball of solid air, like snow, collected around it. But since then this record of coldness has been far surpassed. In 1908, a temperature of 270° C. below zero (only 8° above Absolute


A MODERN FORM OF THE SPECTROSCOPE
ALDEBARAN
TELESCOPE TO COLLECT LIGHT FROM STAR
PRISM TO SEPARATE RAYS & FORM SPECTRUM
TWO EXAMPLES OF SPECTRA
THE SUN
SODIUM
THE SODIUM BAND

Notice in the Sun's spectrum the band denoting Sodium.

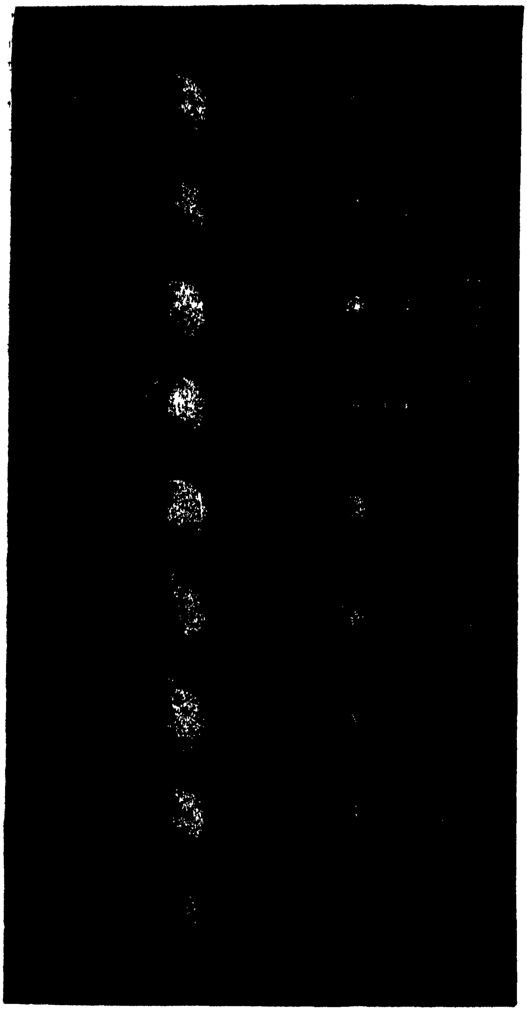
It is exactly parallel to that in the adjoining diagram (spectrum of Sodium alone), every substance having a definite series of lines of which the positions are constant.

How the Spectroscope Reveals the Composition of the Stars

The prism splits up a ray of sun- or star-light into a coloured band—the different colours being separated by black lines, which form an index to the incandescent substances of the sun's atmosphere. Astronomers, by the comparison of the celestial spectra with those of vapours of various terrestrial elements, can determine the composition of the sun and stars

zero) was reached, and helium was at last obtained as a liquid.

As soon as helium was found in the air, other sources were looked for. A million *volumes of air contain only four of helium, and consequently only very tiny quantities* of the gas could ever be hoped for if it were not to be found in greater relative abundance elsewhere. The American chemist Hillebrand had already noticed that a uranium mineral, Cleveite, contained large quantities of an inert gas which was thought to be nitrogen. At the suggestion of Sir Henry Miers, Ramsay obtained some of the material and examined the gas with the spectroscope. Helium was found again, this time in quantities which were less difficult to deal with. So brilliant was its spectrum that all the lines were seen, not *only the intense yellow one, but also two red lines, a green, a peacock blue, and a violet. In this case, just as in 1868, a* remarkable coincidence attended the discovery, for a few weeks later Langlet found helium quite independently in the same mineral, and this, curiously enough, had been called Cleveite, after the mineralogist Cleve, in whose laboratory he was then working.



Drawn by John Gauld

The Disintegration of Uranium

As the result of the exploration for helium which was stimulated by the success of Ramsay and Langlet, it soon became known that helium was invariably to be found in all uranium- and thorium-bearing minerals. Pitchblende, which is now well known as the most important source of radium, proved to be richest in its store of helium, and Monazite, from which the thorium used in the manufacture of gas mantles is extracted, also contained the now familiar element. Why does helium occur so exclusively in association with uranium and thorium ? For five years this problem remained an unexplained mystery, and to realise its profound significance, we must now turn to the new science of radioactivity, then in its infancy.

In 1896, Becquerel, inspired by the discovery of the Röntgen rays, found that uranium salts were able to give out a radiation which, unlike ordinary light, was capable of penetrating black paper and making itself evident by its effects upon a photographic plate wrapped in the paper. This observation marks the commencement of a harvest of wonderful discoveries that have entirely revolutionised our conception of the structure of matter. Madame Curie at once began an exhaustive examination of all the other known elements, and came to the conclusion that thorium alone possessed " radioactive " properties similar to those of uranium. The radiations were then studied in great detail by Rutherford, who found it possible to analyse them into three well-marked types, the Alpha or α-, Beta or β-, and Gamma or γ-rays.

The β-rays have been proved to consist of tiny, electrically-charged particles, having only one seventeen-hundredth of the mass of a hydrogen atom, and ejected with an inconceivably high velocity, sometimes even approaching that of light itself. The γ-rays are similar to the Röntgen rays, and their nature is still a matter of dispute. It is, however, with the α-rays that we are here particularly concerned. By their behaviour in a strong magnetic field, Rutherford concluded that they consisted of positively charged particles, some of which move with a speed of 12,000 miles a second. The story of the brilliant researches which culminated in the determination of the mass of an α-particle, and of the charge which it carries, is one of the most fascinating in the annals of science. But here it must suffice to say that as a result it was predicted in 1902 that the α-particle was a charged atom of helium.

The origin of the α-particles is to be found in the disintegration of the radioactive elements. An atom of uranium is essentially unstable, and sooner or later it will explosively break up, emitting an α-particle, and leaving a residual atom behind. This in turn breaks up in a similar way, and again an α-particle is ejected. Altogether eight α-particles are disentangled from the recesses of the original atom of uranium, and of the elements which are formed on the way, radium is the best known. In a similar manner, thorium slowly breaks down, and each original atom is responsible for the liberation of altogether six α-particles.

Now comes the proof that the α-particle is actually an atom of helium. In 1908, Ramsay and Soddy set out upon this difficult task. They prepared a glass tube so thin, that while an α-particle could pass through it, the ordinary molecules of a gas were retained. Into this tube was placed a gaseous radioactive element known as Radium Emanation—the next in the line of descent to radium itself—and the tube was then fitted into an outer vessel. The α-particles passed into the latter, and in the course of a few hours the gas which had been slowly accumulating, atom by atom, was found to give the helium spectrum. Helium had appeared in the outer vessel where previously none whatever had been detectable. It has now been conclusively proved in this delicate and beautiful way that uranium and thorium and all the daughter elements which liberate α-particles are capable of providing a supply of helium. The curious and at first puzzling association of helium with minerals containing the radioactive

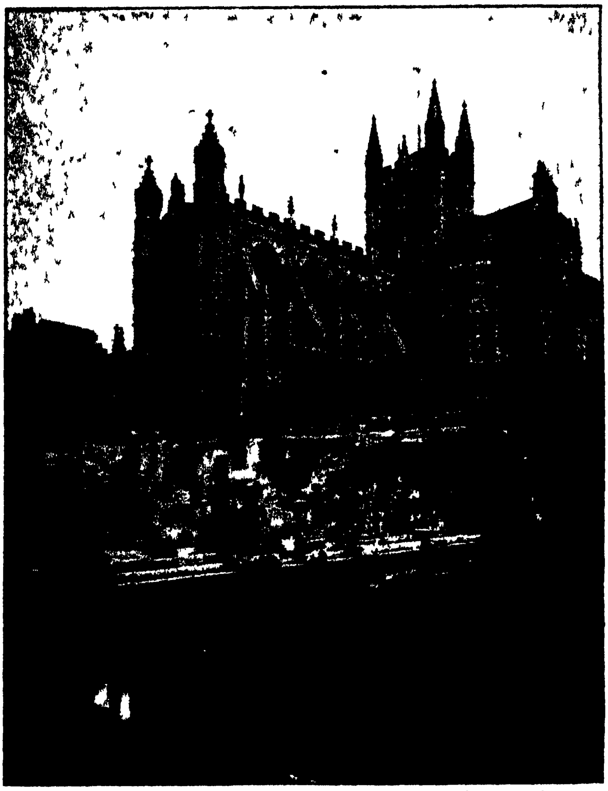


Photo Graphotone Co

The Roman Bath, at Bath, which contains Helium *parent elements thus finds a complete and entirely unanticipated explanation.*

The presence of helium in the sun is more significant than its discoverers ever dreamt. If there is helium, we may confidently expect that radium and uranium are also present, and already the spectroscope has indicated the probable existence of these elements in the sun.

The King's Bath

Helium, unknown twenty years ago, except as a line in the spectrum of sunlight, is now found not only in the atmosphere and in hundreds of minerals, but also in the gases which arise from the craters of certain volcanoes, and in the waters of innumerable wells and springs. One of the best known cases of the latter was discovered by Lord Rayleigh at Bath. From the surface of the water in the well of the King's Bath, bubbles of gas are constantly rising. The gas consists almost entirely of nitrogen, but one part in a thousand is helium. The suggestion that its presence indicates the existence of radium in the rocks from which the well draws its supplies of water was proved to be correct by Professor Strutt, who succeeded in finding minute traces of radium in the deposits on the side of the well.

The study of helium has led to two of the most remarkable and least expected of scientific triumphs. Helium atoms have actually been visibly detected and individually counted, and to-day we know by direct measurement that from one gram of radium there is liberated every second thirty-four thousand million atoms of helium. Moreover, knowing the volume of helium which accumulates in a given time, it can at once be calculated that each cubic centimetre of the gas contains twenty-seven million million million atoms. This leads on directly to the fascinating question of geological time. Applying the knowledge we have already gained, it is obvious that if a mineral contains radium, then *helium must have been slowly accumulating in that mineral ever since its original formation in the rocks of the earth's crust.*

Atom after atom the helium has ticked out the life of the mineral, and the quantity of the gas which has now collected, when compared with the radium from which it has been derived, gives us a valuable method of measuring the age of the mineral, and therefore, in many cases, of the rock in which the mineral was found. Some most surprising results have been obtained by Professor Strutt, who discovered that certain minerals were at least 700 million years old. We say "at least," because not all the helium which was originally enclosed in a mineral can be measured. From the time when the mineral is removed from the rock, helium is constantly escaping, and probably only half, or even less, remains when the difficult estimation is actually made. The ages found are consequently all too small. However, helium is not the only element which accumulates. Lead also is formed at the expense of its radioactive parents, and the present writer, using lead as the criterion of age, has found that some minerals must have existed for 1,500 million years. Other minerals, of course, are very much younger than this, and indeed some have been formed so recently, that no detectable amount of lead has had time to accumulate.

Recent Experiments

Recent experiments made by Sir W. Ramsay, in which helium again mysteriously appeared, have opened up afresh the long-despised subject of the transmutation of the elements. The old alchemists may not have been altogether wrong in their fanciful notions of the constitution of matter, but during their time scientific methods were crude and immature. To day the time is ripe for even more astonishing discoveries than any which have yet been made, and the scientific world is eagerly awaiting the results of the researches which are now in progress.

Organ Cacti in the Mexican Desert

Photo. C. C. Jones & Co.

The Victor of the Desert

How the Cactus Lives and Thrives in the Hot and Barren Wilderness

By S. LEONARD BASTIN

Author of "Wonders of Plant Life," &c.

AS far as we know, life cannot possibly exist without a certain amount of moisture.

A very good illustration of the amazing effect of moisture upon the vegetation of a district is to be found in the wonderful luxuriance of plant growth on the Mountains of the Moon. As is well known, Ptolemy considered that somewhere in the centre of Africa there existed a vast range of mountains, amongst which was to be found the source of the Nile. The range was known as the Mountains of the Moon, and it is now generally considered that the heights of Mount Ruwenzori and its fellows, discovered by Stanley, were those of which the Greek geographer had heard. A notable feature of the climate on the slopes of Ruwenzori is its intense humidity, and it is said that it is possible to live near to this mountain for six months without once catching a glimpse of the peak, owing to the thick curtain of fog. It is this very dampness of the atmosphere which makes it possible for plant life to grow with an astounding vigour, even at an immense altitude. A glance at the double-page illustration will bring before the reader a vivid impression of the flora on the upper slopes of Mount Ruwenzori. The actual spot at which this picture was taken is 12,000 feet above sea-level! At such an altitude, as a rule, even in the Tropics, the vegetation is sparse, largely owing to the drying action of the wind. But, given plenty of humidity, it is clear that plants grow with great freedom, no matter what the elevation may be.

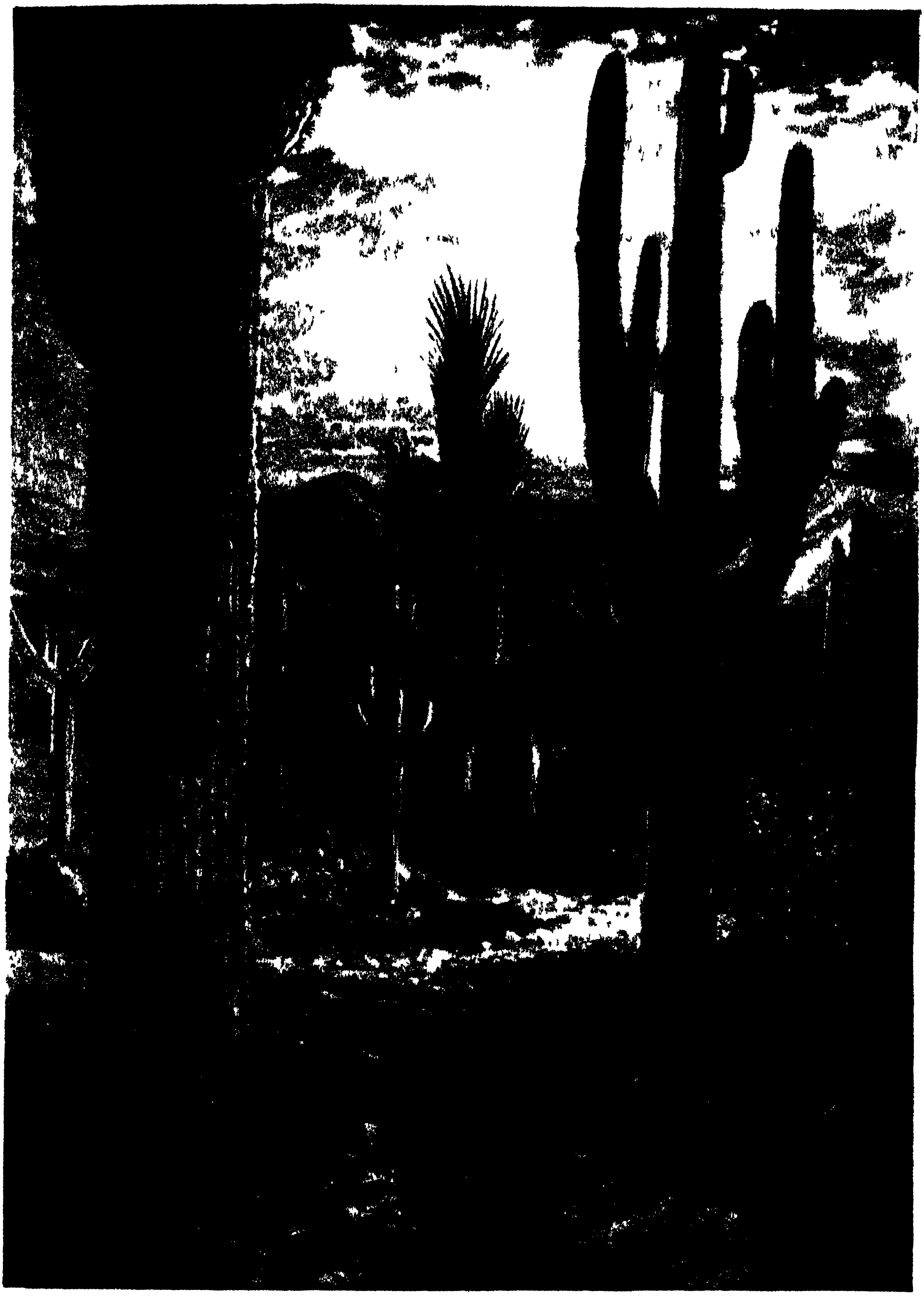
It is the absence of moisture which accounts for the barrenness of the desert. In many of the arid regions the country would be of the most fertile nature if water were only present, for the soil is rich in those mineral matters which plants can turn to such good account. Yet, in spite of the terrible dryness of the desert, there are very few regions which have not been invaded by that singular group of plants of which the Cacti are so typical. These plants have dispensed with foliage altogether, and are little more than succulent stems covered with a thick skin which keeps in the moisture of the juicy shoot.

The Water Barrel of the Desert

So called from the fact that it contains within itself a fluid not unlike water, which is much appreciated by thirsty animals

It is interesting to consider the conditions with which these plants have to contend. During the day time, at any rate, most of the deserts are most terrifically hot. Experiments in the Mexican deserts have shown that after hours of baking in the sun the sand in which the plants have to grow may be as much as 200° F.—not far short of boiling point. Yet so perfectly are the Cacti and similar plants protected by their skins that a thermometer placed inside the body of a specimen plant only showed a temperature of 55° F. In addition to the fierce heat by day there is the cold at night, a matter which few people think of in connection with deserts. In a region which for a large part of the year is almost rainless, the sky is exceedingly clear; thus, after sundown, the earth parts with its heat very freely. This is so much so that the temperature, even in a tropical desert, may at night fall to freezing point. Thus in the desert-like plains of India it has been a custom for an immense time to place out shallow trays of water during the night. This is frozen, and the ice is stored away underground for future use.

Most serious of all the desert conditions is the dryness. Of course, there are just a few regions in the world which are absolutely rainless, but in most of the deserts a certain amount of moisture falls. This



By The arreras

The Victor of the Desert

Experiments in the American desert have shewn that, after hours of baking in the sun, the temperature of the sand in which the cacti have to grow may be as much as 200° F. Yet a thermometer placed within the stem of a cactus registers only 55° F.

may be very little, for in some deserts it is known that rain does not occur on more than about ten days in the year. All the rest of the time the terrible sun blazes down from a cloudless sky. Yet the Cacti and other succulent plants are very well able to conserve their moisture. This is accomplished in several ways. Of course, the very shapes of the plants are all in their favour. Being either round, globular, or cylindrical, they offer a limited surface to the dry air inconceivably less than a plant of the same size bearing a quantity of leaves. As well, too, the thick skins play a big part in keeping in the moisture, and many kinds of Cacti, such as the sort known as Old Man's Beard, are covered with dense masses of hair. One may say that whilst we put on a coat to keep out the wet, the Cactus does the same kind of thing to keep the moisture in.

The Cacti are able to retain their moisture for an astonishingly long time. By way of experiment one of the American Giant Cacti was taken up and kept without water. The plant lived for more than a year and a half—a wonderful illustration of the power of these singular plants in retaining moisture. Another remarkable instance of the vitality of the Cactus came under the notice of the writer. A fine specimen of the Old Man's Beard kind, which had died away from the roots, was placed in one of the museums at Kew. Several years later the curator was rather struck with the appearance of the upper part of the plant. An examination revealed the remarkable fact that about eighteen inches of the topmost portion of the Cactus had actually taken root in the lower part of itself, and was really growing! The enterprising plant was placed in a pot and given a position in a greenhouse, where it is probably alive at the present day.

The Giant Cactus of the American Desert

These plants are little more than succulent stems covered with a thick skin which retains the moisture of the juicy shoot

As may be imagined, the Cacti and other succulent plants of the desert are very subject to the attacks of animals; in the parched regions the thirsty creatures long to eat the juicy stems which, in many cases, are not unpleasant to taste. It is not surprising, then, to find that all these desert species are remarkably well defended.

THE WONDERFUL LUXURIANCE OF F

(From a

A notable feature of the climate on the slopes of Ruwenzori is its intense humidity. At such an altitude a largely owing to the drying action of the wind. But, given plenty of hu

OWTH ON THE MOUNTAINS OF THE MOON

harles Alluaud)

natural garden shown here, nearly 12,000 feet above sea-level, the vegetation is usually sparse, even in the Tropics, lear that plants grow with great freedom, no matter what the elevation may be

Photos S. L. Bastin

How Cacti Protect their Flowers

One of the commonest methods employed is that of arming the plant with thorns. Now some of the Cactus thorns are simply terrific, and in the case of a sort of prickly pear, well called *Opuntia formidabilis*, the spines are ten or twelve inches in length! No wonder such plants are largely used in tropical countries for hedging. It is certain that they are far more effective than barbed wire. In some cases the spines are poisonous, whilst in others they are barbed, so that the most terrible wounds would be caused if an attack were made on the plant. As stated on p. 540, thirsty Mexican ponies suffer severely when trying to get at the juice of the Cacti.

Many of these succulent desert plants grow to a great size. Thus the Giant Cactus sends up a tall column, often with only a very few branches, which may be 80 or even 100 feet in height. Some years ago a monster Cactus was brought from Mexico to Kew Gardens. The plant was semi-globular in shape, and it was nearly 10 feet in circumference, and weighed at least a ton. It required ten strong men to place the plant upon the weighing machine. Unfortunately, the plant died after a few years. Naturally such huge plants as this must be a very great age. Many Cacti grow so slowly that they are hardly seen to increase during a man's lifetime. No very definite means are available of determining the age of these strange plants, but some of the large examples which have been discovered cannot be less than a thousand years old, and may very well be a good deal more.

Curiously enough, some of these inhabitants of the desert produce the most beautiful flowers. This is especially the case with the Cacti, whose blossoms are without rival in the whole world. The various kinds bear flowers of every conceivable shade except blue, and the blooms are often of an immense size. It is not unusual for the blossoms to measure 18 inches, or even two feet, across.

Wonders of Life in the Ancient World—II

Birds and Mammals of the Secondary Epoch

By SIR H. H. JOHNSTON, G.C.M.G., K.C.B.

SO little is known concerning extinct birds as compared with the record of marvellous reptiles and mammals, that an account of them from the "wonder" point of view need not occupy much space.

BIRDS

The most celebrated and the oldest fossil bird is the far-famed Archæopteryx, scarcely larger than a rook, of which two specimens, representing two species, were found in the slate quarries of Solenhofen, in Bavaria, a formation dating from the Jurassic period or the middle of the Secondary Epoch. Archæopteryx was a bird rather than a reptile, though like all ancient birds down to the commencement of the Tertiary Epoch, it possessed teeth in the jaws. (It is quite possible that birds of an otherwise modern type continued to develop teeth in the jaws, even after they had differentiated into the main divisions of their modern classification, each order losing these vestiges of teeth in course of time). The structure of the fore-limb or wing shows three complete fingers (instead of incomplete, like those of the modern bird) each terminated with a claw (only two of the fingers are clawed in modern birds). Some biologists consider that only the terminal phalanges of these fingers with the hooked claw were free of the patagium or wing-membrane and the feathers in Archæopteryx; and that restorations which show two or three fingers as quite detached from the wing are erroneous. Others, again, think that the thumb and first finger of Archæopteryx were movable and free from the wing covering. The leg and foot were like those of the modern bird especially of the Passerine type. On the sides of the thighs quill feathers seem to have grown like those of the wings.

The tail is a remarkable feature in Archæopteryx. It is long, and consists of twenty-one to twenty-two vertebræ, which gradually decrease in size till they end in a small nodule of bone. The tail-feathers spring from the last twelve of the vertebræ. But the great difference in this respect between Archæopteryx and modern birds is exaggerated. We read in most books that the tail of the modern bird consists of a small number of partially fused vertebræ, ending in one very big recurved bone called the pygostyle, and that from this terminal mass of the tail-bones the quilled tail-feathers radiate. But not all modern birds have this pygostyle. In the modern Rhea and some of the recently extinct Moas of New Zealand it is not present, and in these, as in some other birds of primitive features, the tail vertebræ are less fused and extend to a greater length. It simply means, therefore, that in the course of ages the bony stem of the tail of birds grew shorter and shorter, and that the tail-feathers were attached in a more and more fanlike direction to the terminal vertebræ.

Evidently, birds had not long been established before they began to develop many divergent forms, leading widely different kinds of life. Archæopteryx was a tree-frequenting bird of large wings, though possibly of somewhat feeble flight. But *Ichthyornis* was a toothed bird of long and extinction. Some biologists think that for similar reasons—the need of constant flight from enemies and the danger of nesting habits—the principle, firstly of carrying the eggs in a pouch of the mother's body (Penguins are developing similar recesses at the present day for incubation), and secondly, the development of viviparous young, may have arisen from the incessant persecution of the early mammals by reptiles and birds.

It was not until the very beginning of the Tertiary Epoch that the great mammalian prosperity and differentiation began. In some part of the earth's surface we shall yet discover geological horizons intermediate between what is at present the abrupt close of the Secondary Epoch in the last of the chalk strata and the commencement of the Tertiary with the Eocene clays; and in deposits of this intermediate nature find clues to the mysterious closing of the Reptiles' reign—the extinction of Dinosaurs, Pterodactyls, and Mosasaurs, and the evolution of the modern or eutherian type of mammal. But so far as palæontological research goes, we are no sooner at the very commencement of the Tertiary strata, the beginning of the Eocene, than we find an earth peopled with mammals in immense numbers, belonging to some of the differentiated orders represented at the present day.

Eocene Period

We are compelled for many reasons to believe that what is known as the Eocene period must have been an age of more than two or three millions of years, to account for the astonishing variety of Fish, Lacertilian, Bird, and Mammalian types, which were then developed. During the various stages of the Eocene there came into existence not only the varied families and genera of marsupials similar to those still living in Australia and America, but the orders of the Primates (Man's ancestors), the Insectivores, Rodents, Carnivores, Whales, Ungulates, and Edentates; perhaps even the Bats, already specialised for flight. Before the Eocene was passing through the Oligocene into the Miocene, the carnivorous type had reached its most extravagant development, not merely in the ancestral Cat, but in the Sabre-toothed "Tigers." (A better name for this group is Machairodont—sabre-toothed—as they were not specially allied to tigers; the tiger is a true cat of very modern origin. The Machairodonts were the extreme of mammalian ferocity—felines preserving some primitive features lost by modern cats, but adapted in teeth and jaws for slaying beyond any other mammal.

The Machairodont

The mouth of the Sabre-toothed Tiger (which type did not reach its culmination, however, till the close of the Miocene), could open with a gape that must have measured a foot and a half in the biggest examples. And thus the twelve-inch long, flattened, sabre-like, serrated canines of the upper jaw could be plunged for all their length into the neck or body of some great herbivore, aided by the leverage exercised by the prolonged chin, with its massed incisors and stunted canines. The molar teeth, reduced to two on each side, served only to sever, not to masticate, parcels of flesh. These gobbets must have been swallowed whole; or possibly the extreme form of the Machairodont lived mainly by blood-sucking, after severing the great arteries with its teeth. The biggest and most awful of the Sabre-tooths (*Smilodon neogeus*) lived in South America, lingering on almost to the human period in that region; while in Europe and Asia its near allies of the same genus were certainly contemporaneous with man. Indeed, in England the Sabre-toothed "Tiger" was possibly still in existence 100,000 years ago, when Palæolithic man had begun to take possession of the caves.

The True Cats, as distinct from the Machairodonts, apparently originated in Europe, and did not reach America till quite late in geological history. The Machairodonts were also European in their

Arsinoitheres Attacked by a Pack of Hyænodonts

(Restoration by Charles R Knight under the direction of Professor Osborn)

The Arsinoitheres were the giant mammals of the Eocene period They had [illegible] snout and a small pair above the eyes A moderate sized male stood 5 ft. 9 in at the withers and measured 9 ft. 2in. from snout to rump The ferocious carnivorous Hyænodonts were adapted to capture either land or water-living prey birthplace, finding their way to North America at a later date. But although America at the present day has no feline larger than the Jaguar, it seems to have possessed—at any rate in north and northernmost America, as late as the Pleistocene—cats as large as the Lion and Tiger; in fact, in all probability, near relations of the Tiger. The Tiger would seem to be of Asiatic origin, and never to have reached Europe, but to have extended its range to Arctic Asia (where its bones testify to its existence at no very distant date, well within the Arctic circle, on the New Siberian islands), and perhaps across the former Bering Isthmus into Arctic and Temperate North America. The Lion, which like the Jaguar and Tiger sprang from a Leopard ancestor (from a stock chiefly rosetted and spotted, but also striped), is most at home—so to speak—in France. The most primitive and jaguar-like type of Lion hitherto discovered has been found in early Pliocene strata in Southern France, while the extremest development of the Lion type also came into existence in France—the Cave Lion, which extended its range over nearly all Germany, England, North Italy, Switzerland, and Austria. Its somewhat degenerate descendant, the modern Lion (differing only from its ancestor by its much smaller size) ranged far afield, into Spain, Africa, Western Asia, and India.

The Lion and Tiger

In North Africa the primitive Carnivores (Creodonta), the earliest of which resembled much the ancestral Ungulates, Insectivores and Primates, gave birth to the Whale type during the Eocene, and this large, long-headed, fish-eating mammal first frequented the rivers of the Nile region and then taking to a sea life (especially in the Mediterranean and Caspian) soon replaced in the great oceans of the world the vanished Fish-lizards and Mosasaurians (if, indeed, the last-named have completely vanished and are not still represented by a few "Sea-serpent" examples). The Edentates—no doubt, an indeterminate type descended from the generalised form of the earliest Eutherian—found their securest refuge and home of development in South America, just as the Marsupials did in Australia. In South America the Edentates grew into monstrous Armadilloes and gigantic Sloths.

The Ungulates quite early in the Eocene were large beasts. In Egypt their primitive types (not unlike the modern Hyrax) grew by degrees into the long-snouted, long-tusked elephants, or into the monstrous Barytherium of Egypt, and the Titanotherunds of North America, with an anticipation of Rhinoceros horns; or into the many-horned and sabre-tusked Dinoceras and Tinoceras of North America, or the monstrous Toxodonts of South America (like gigantic Rodents). During the Eocene, however, most of these monstrosities died out without leaving descendants, and the line of Ungulate development in size and wonder followed the two groups of Perissodactyls and Artiodactyls—the Odd-toed and Even-toed Ungulates. From the ancestral Elephants (such as *Palæomastodon*) there had sprung the extraordinary Tetrabelodons, Dibelodons, and Mastodons, the first-named with long incisor tusks in both jaws, the last-named as large as or larger than modern elephants, with huge tusks in the upper jaw only; also the Dinotheres, with tusks confined to the bent-down lower jaw. Then, lastly, the true elephants of Africa, Asia, Europe, and America—the straight-tusked forms (of which *Elephas antiquus* was a surviving example well within the human period (and the monstrous mammoths of Europe and North America, or the wellnigh incredible Ganesa Elephant of India, whose remains can be seen in the Natural History Museum, London, and whose tusks seem so huge, and so long that they must have eventually tired their owners out of existence.

The Ganesa Elephant

The Sirenians were quite a side issue of the Ungulate evolution. They originated

Hunting the Modern Moose-deer in Canada

(Drawn by Cyrus Cuneo)

The deer, of which the modern elk or moose is one of the most marvellous developments, probably originated in the Old World and spread thence to the American continent from creatures near the ancestral elephants and hyraxes, which, though strictly vegetarian in diet, took to a water life, and became in course of time such creatures as the recently-extinct Rhytina—a bulky water beast of North-east Asia—the Manati, and the Dugong.

The Elasmotherium

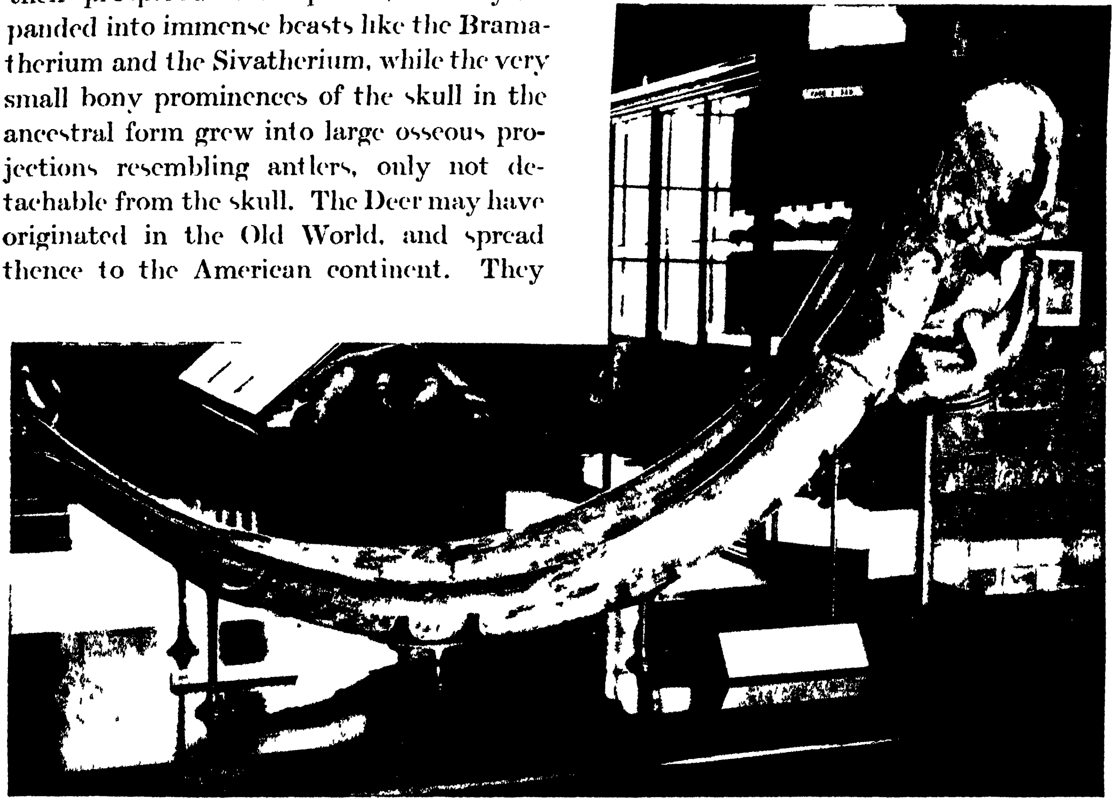
In Europe and North America the early Perissodactyl Ungulates threw off forms like ancestral Tapirs, and very soon revealed the Rhinocerontine group. This reached its most extravagant development in Northern Asia in the form of the Elasmotherium. It was of the bulk of an elephant, and the larger of its two horns (that which grew from the middle of the forehead) may have measured something like six feet in length, judged by the size of the base of the parallel instance of the long-horned White Rhinoceroses of South Africa. The Elasmotherium was extremely specialised in other directions, and probably died out (as so many forms of life must have expired in past ages) from being made too wonderful for this world, requiring too intricate a balance as regards climate, food, and general surroundings.

The Rhinoceros family was abundantly represented in North America (where, indeed, it seems to have originated), but died out there long before the human period, its last examples having departed from the Rhinoceros ideal and gone in for lightness of structure and speed, so that they must have borne a superficial resemblance to clumsy horses. But the true Rhinoceroses (if we regard Elasmotherium as an aberrant culmination) reached their greatest modern development in Europe and Northern Asia in the form of the Woolly Rhinoceros, which belonged to the group represented by the living rhinoceroses of Africa, and was, in fact, what one might call a very extreme form of the modern White Rhinoceros, which had not, however, parted from the possession of hair on the skin, as is the case with its living relations in Africa. Under the influence of the increasing cold of the Glacial periods this great two-horned rhinoceros grew a thick woolly coat over its hide. Its horns were in their maximum development greater in length than those of the wonderful White Rhinoceros of South Africa, which in former times frequently attained a length of five feet. Much earlier in palæontological history there occurred large two-horned rhinoceroses in Europe (such as *Rhinoceros schleiermacheri*), which possessed the same number of incisor teeth and canines as may be seen to-day in their near relations, the much smaller two-horned rhinoceroses of South-east Asia.

The development of the Horse, from a small beast not bigger than a sheep, with three or four toes on each foot, to a creature like the existing Wild Horse of Central Asia, is one of the stock illustrations of Palæontology, and need not be further described here. Apparently, the True Horses (of the *Caballus* sub-genus) first originated in Central Asia, and the ancestors of the Zebras and Asses in Europe. A very large equine—bigger than any wild species of the present day—was evolved in South Africa. It was probably a gigantic Quagga. Another large and clumsy equine with a very big head (Hippidium) was developed during the early human period in southern South America, with no near relationship to the actual horses, but the descendant, no doubt, of one amongst the many equine forms that once flourished in North America. From Asia the true Caballine horse extended its range into North America and existed there in enormous numbers down to some fifty thousand years ago, when it became extinct.

The Giraffe

The most extravagant development among extinct Even-toed Ungulates occurred in the Giraffe family. This group apparently arose from a generalised type of Ruminant in North America—some such type as was ancestral to the modern Prongbuck, and near to the base from which Deer, Tragelaphs, Antelopes, and Oxen, were subsequently derived in the Old World. The primitive giraffes must have reached Asia from North America in the Miocene period, and have here found a favourable ground for their prosperous development, for they expanded into immense beasts like the Bramatherium and the Sivatherium, while the very small bony prominences of the skull in the ancestral form grew into large osseous projections resembling antlers, only not detachable from the skull. The Deer may have originated in the Old World, and spread thence to the American continent. They likewise had their marvels of development (among which the modern Elk or Moose may truly be classed); for in the Megaceros, or Gigantic deer (*Cervus giganteus*) of Europe and Western Asia, which seems to have been an outgrowth of the Fallow Deer sub-genus, the antlers reached such a size and development as has never yet occurred in the form of bony projections in any other known mammal. The "Irish Elk" (as the Megaceros is sometimes called on account of its having reached its greatest development in Ireland) was also of very considerable size in body. Its existence was brought to an end by primitive Man, more than by any other cause.



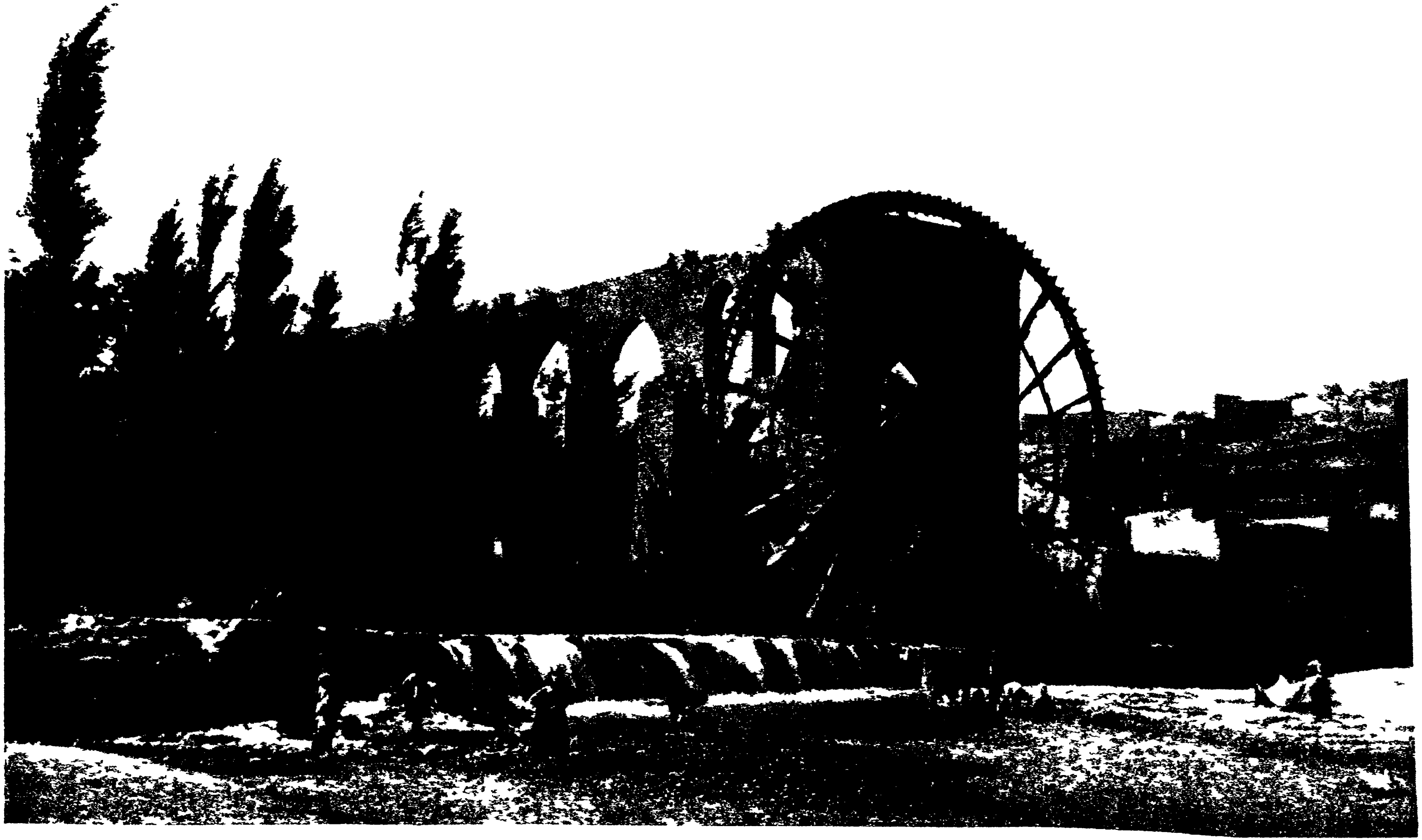
Photographed in the Natural History Museum, London

Remains of the well-nigh incredible Ganesa Elephant of India

Its tusks are so huge and so long that they must surely have tired their owner out of existence

Amongst the Bovines in ancient days, several notable wonders were created. There were gigantic Bison both in Europe and North America which were almost twice the size of the big bison of to-day.

A near relation of the ancestral type (if not, in part, the ancestor itself) of our modern cattle, was the superb *Bos primigenius* or Urus of Western Asia, Europe, and North Africa, with horns in the bull which must have measured four feet round the curve. But the most noteworthy example of huge horns amongst the Bovines was in the extinct Buffalo of North and South Africa—*Bos antiquus* or *Bos baini*—in which the horns must have reached to something like fifteen feet in length from base to tip! For in the largest examples which are found in the surface formations of North and South Africa the bony cores of the horns alone measured as much as fourteen feet in length.



The Largest Water-raising Wheel in the World

The water wheels at Hama are driven by the flow of the river on what is known as the undershot principle, that is to say, the wheel is moved by water passing beneath it The largest that shown in the accompanying illustration has a diameter of 75 feet. Around its outer rim are the buckets which raise the water to be deposited in the aqueduct at the top

I.—On the Land: Artificial

The Largest Water-raising Wheel in the World

By H. J. SHEPSTONE

ALTHOUGH *it is only within comparatively recent times that man has harnessed falling water for driving turbines, in order to generate power in the form of electrical energy, the ability of running water to turn wheels was long recognised by the ancients. Indeed, one of the first mechanical inventions was undoubtedly that of the water-wheel. They were used by the ancient Egyptians and others. Types of the wheels they employed may even be seen to-day on the banks of the Nile, and on the Euphrates.

Ancient Invention

The wheels, built of wood, and set vertically in the stream, are turned by the weight of the moving water striking the bottom rim. This is what is known as the undershot principle. The huge wheel shown in the accompanying photograph is an undershot water-wheel on the banks of the river Orontes, at Hama, a picturesque city in Northern Syria. It is interesting in that it can claim the distinction of being the largest water-raising wheel in the world, if not the largest of all water-wheels.

There are three other large wheels at Hama in addition to the one mentioned, and it is not surprising to learn that these constitute one of the principal sights of the town. Placed upon the banks of the river, that flows through the city in the form of an **S** amid the trees and gardens, these old wheels are a constant element of beauty, which is further enhanced by the black and white striped domes of the mosques, and the ancient citadel that dominate the town. They draw up the water of the Orontes for irrigation purposes, and also for supplying the town.

The giant of these wheels has a diameter of 75 feet. Upon its outer rim are a series of wooden buckets, which raise the water and deposit it in the stone aqueduct above, from which it is carried to the surrounding orchards and vineyards. Like its companions, it is built of wood, a dark mahogany, the only ironwork about it being the axle. The creaking of the wheels is incessant, day and night, and is heard long before the wheels come into view. They never stop. In winter and early spring the flow of the stream is partially blocked to reduce the rapidity of the revolutions, but on no account are the wheels actually stopped, lest it should prove impossible to start them again.

The wheels are the property of the four Lords of Hama, after whom they are named —Azam Zadeh, Teifur, Killani, and Barazi. Just where the river makes a pretty sweep there is the Killani wheel. In the picturesque old residence adjoining it is a mausoleum, where three of the family ancestors are buried; the rooms looking over the river are filled with the pleasant grumbling of the old wheel. Hama's four rulers, powerful Mohammedan families, constitute the aristocracy of the town. Their combined income is said to be £6,000 a year, all derived from land and villages watered by these old wheels. Before the Ottoman Government was established as firmly as it is now, these four families were the ruling Lords of Hama and the surrounding districts; they are still of considerable weight in the administration of the town, and the officials of the Sultan let them go pretty much their own way.

Lords of Hama

II.—In the Underworld: Artificial

[illegible]

Entrance to a Dene Hole in Stankey's Wood

The Mystery of the Dene Holes

The True Explanation of a Mystery that has Puzzled most Archæologists

By ERNEST A. BAKER, M.A., D.Lit.

Author of "Moors, Crags and Caves of the High Peak," &c

IT is rather astonishing and very tantalising to think that, within a radius of twenty miles of Charing Cross, there exist hundreds of deep excavations about the date of which, and the actual makers, we have less positive knowledge than about the origin of the Pyramids. At Bexley, within a stone's throw of the road to Dartford, there is a group of dene holes, one of them 90 feet deep, with a fine, dome-shaped chamber at the bottom, 30 feet high and 40 feet in diameter. These lie in a patch of woodland called Stankey's Wood, in the small area of which there are perhaps fifty others, though only a score or so are actually open, a serious danger to dogs, wild animals, and even human trespassers into the covert. Stankey's is an outlying part of a larger area of forest land, called Joyden's Wood, which abounds in scattered dene holes. Another detached portion, known as Cavey Spring (or "the wood of the caverns"), enshrouds a further collection of these mysterious pits, lying so close together that it is difficult to understand how the makers found room beneath the surface to keep their chambers and galleries separate, and not break through the adjoining walls and cause a general collapse. For this is the extraordinary feature of the dene holes: they are crowded together in a small circumference, their mouths gaping less than twenty yards apart; the short galleries in the chalk, 40 feet, 60 feet, or 100 feet beneath the surface, diverge, as a rule, in six different directions; and yet they never, or very rarely, and then only by an obvious accident, come into actual contact.

In the same part of Kent there are at least a dozen spots where similar holes are found. A few years ago I organised a party, which dug through a matted covering of roots and earth in two promising depressions, and laid bare two shafts leading down to well-formed dene holes, so close to London as Abbey Wood. Even within the London County Council boundary, in the parish of Plumstead, a shaft was exposed in the course of road-making, some years since, full of Roman remains; it is believed to have been a dene hole which had been made use of by the conquerors of Britain as a rubbish tip. At Crayford, long before this, an antiquary explored a series of pits with beehive chambers at the bottom containing relics of the Stone Age. It has been repeatedly asserted that Surrey contains none of these strange cavities; but a friend recently took me to an open shaft near Walton Heath which is an undoubted dene hole. Across the Thames, where the sandy soil of Essex overlies the chalk, once more we find dene holes in abundance. Here they are known as Dane Holes, and the current belief is that they were made by the Saxons as hiding places for people or goods in the time of the Danish invasions. Near Grays, in a bit of wild land called Hangman's Wood, there is a noted group of these Dane Holes, which have been carefully explored, the explorers cutting through the thin walls separating the galleries so that one can now wander through a subterranean labyrinth formed by the

How to Descend the Shaft of a Dene Hole

A Typical Gallery

ramifications of fourteen Dane Holes, each radiating in six directions, with the exception of one or two that were never finished. It is very difficult not to lose oneself in this bewildering maze.

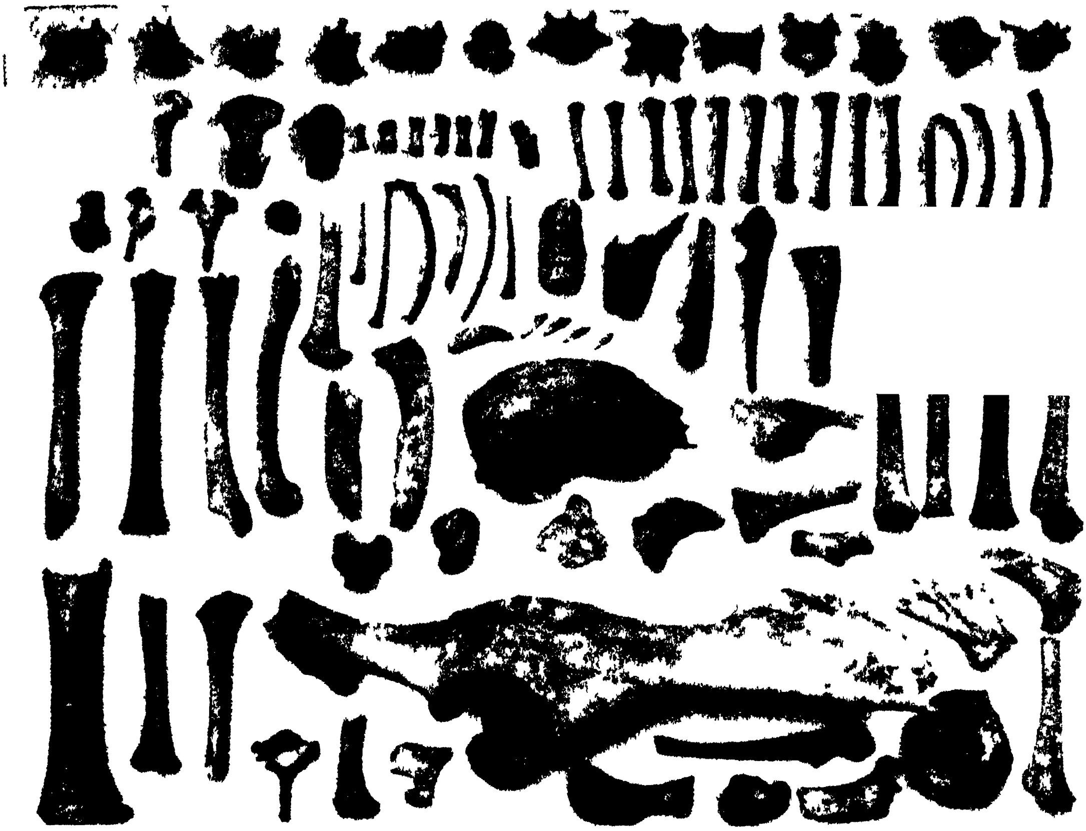
Endless Theories

What are the dene holes? Who made them, and when? What were they made for, and why was such care and trouble taken to keep them separate and distinct? Endless theories have been propounded. Some archæologists aver that they are prehistoric, some that they are comparatively modern. Silos for preserving grain, dwelling places, refuges in time of war, places of burial, places of religious worship, receptacles for prisoners of war, pitfalls for wild animals, and water wells, are some of the uses to which hypothesis has assigned their origin: but neither these theories nor the dene holes will hold water, and the last guess is the most impossible of the lot.

Dene holes, or excavations remarkably like them, have been made in quite recent times for the simple purpose of obtaining chalk. A typical dene hole consists of a good-sized chamber in the chalk, connected with the ground above by a shaft of varying length according to the depth of the chalk below the surface. Obviously, whoever made a dene hole could not help getting chalk; but it does not absolutely follow that they were made merely for that purpose. The immediate object may have been to secure an underground storehouse or hiding-place, and the chalk merely an incident. Why, say the advocates of the storehouse theory, there is often chalk exposed in masses on the surface of the ground within a few furlongs of numerous dene holes: what on earth should lead people to drive a mining shaft to a depth of 60 feet or 80 feet, and why should dozens and scores of these supposed mines be constructed in one small plot of ground, if the sole object was to procure chalk? This sounds mighty plausible, and I thought some years ago that I had discovered weighty confirmation of this more romantic view by detecting in a mediæval French poem, "Perceval, ou le Conte del Graal," allusions to fairy damsels coming from *puits*, or wells, in a forest and entertaining errant knights with food and drink brought out of these repositories. But, while there seems no reason to doubt that the dene holes may at times have been used for many purposes—secret places for the disposal of property when the Danes or other foes were raiding a district, and later on admirable spots for the concealment of contraband in the smuggling days--such purposes must have really been secondary to their original object. They were made to get chalk, and the six-limbed ground plan, which is such a striking feature in nearly all, was simply the most convenient shape for the primitive workman operating without machinery, without a steam-winch, or even a truck running on wheels.

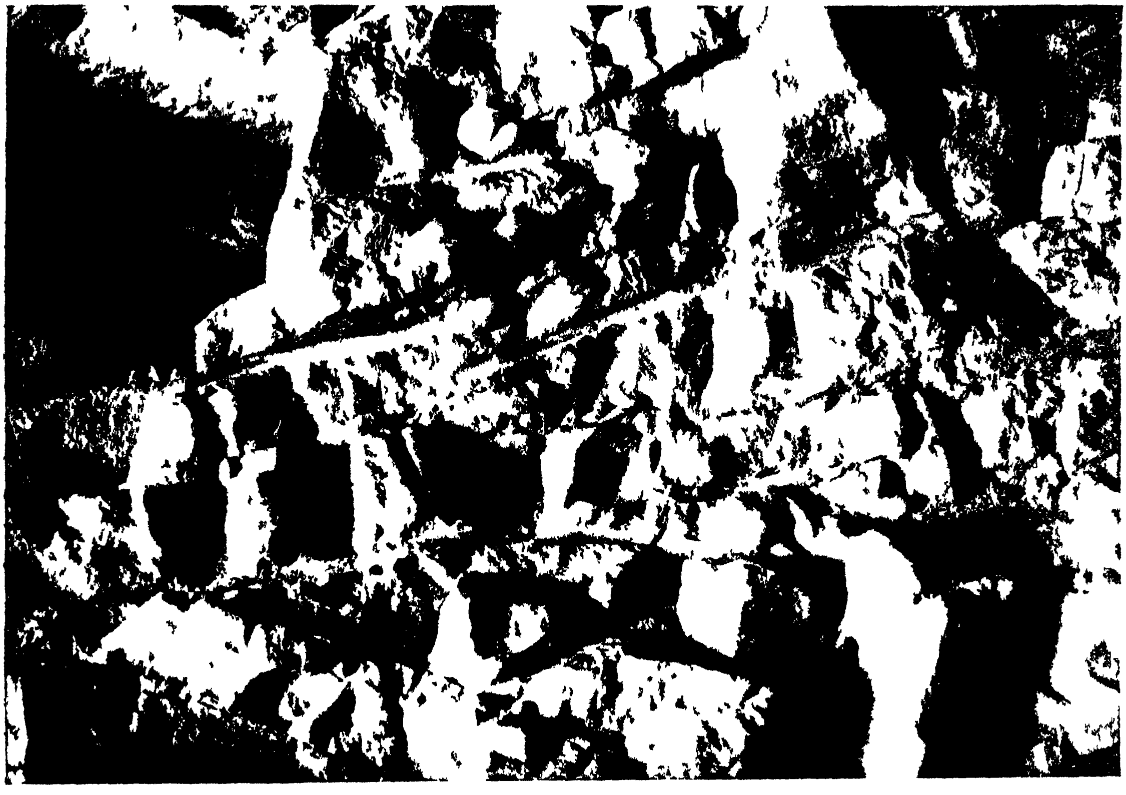
How Constructed

A shaft was sunk through the soft strata down to the chalk, horizontal holes or foot-holds being cut in its sides to enable the miner or quarryman to walk up and down without a ladder, but probably with the aid of a rope hanging from a cross-beam at the top. Then the chamber was gradually excavated, the chalk being put into a bucket attached to the same rope and hauled to the surface. The excavating proceeded in six different directions from the centre, that is, from the bottom of the shaft, and was carried as far as it was possible to drag the bucket and rope, and swing the former back when full under the shaft, to be pulled up. The marks of the rope, where it cut deep into the chalk at the lower edge of the shaft, are nearly always plainly visible to this day. The reason why galleries were not driven farther is simply that a heavy bucket of chalk could not be carried very far without wheels. In modern times, when chalk



Bones Found in Dene Holes

Most of them are regular cemeteries of the bones of wild animals that have fallen in



Tool Marks on the Chalk in a Dene Hole

was being quarried on a larger scale, trucks or wagons were employed, and broad roadways driven for long distances into the chalk, as in the so-called Chislehurst "caves." But whilst the more primitive method was in vogue it paid better, when a further supply of chalk was required—and large quantities were used in past times for marling the fields—to go a few yards away and start a fresh pit. True, there was often plenty of chalk on the surface at no great distance; but that might belong to other owners, and the transport would often be quite as expensive as sinking a new dene hole in sandy soil. Probably several men would be engaged in getting chalk on the same spot at the same time. They would be working in close proximity to each other. But they were paid, doubtless, on the piece-work system, and it would be incumbent on each workman to keep strictly to his own little mine and not break through into his comrade's working.

One of the Six Galleries Radiating from a Central Chamber

Thus we have a complete explanation of the reasons for making the dene holes, and also for what seems their strange form and method of construction, and it all seems like a descent to the commonplace. But the evidences of their antiquity again bring in the possibilities of romance; for we cannot locate the date of them within centuries. I have seen one unearthed by the extension of a great quarry, that had been buried deep under ploughed field for centuries, without a sign of its existence visible on the surface. A grant of land by the Saxon king Eadred, under date 958 A.D., alludes to a "dene pitte," which can clearly be nothing else than one of these ancient holes. This was near Newbury, in Berkshire, a chalk country where no dene holes are reported at the present time. It is hardly possible to doubt that this primitive mode of quarrying for chalk has been in use from time immemorial, the holes dating from the Stone Age being the direct ancestors of others made in comparatively modern days. The so-called "caves" at Chislehurst, which have been described seriously as an underground temple, constructed by the Druids, are not antiquities at all in comparison with the dene holes. The present writer has talked with a man who remembers the digging of the so-called "Roman well." These miles of underground passages are nothing else than a disused chalk-mine laid out on the same principles as an ordinary coal-mine, with broad ways for carting the material in trucks to the exit. The alleged dene-holes are shafts up which the chalk from the older portions was hoisted to the surface. In the borough of Woolwich there are two vast networks of similar construction being worked for chalk at the present time.

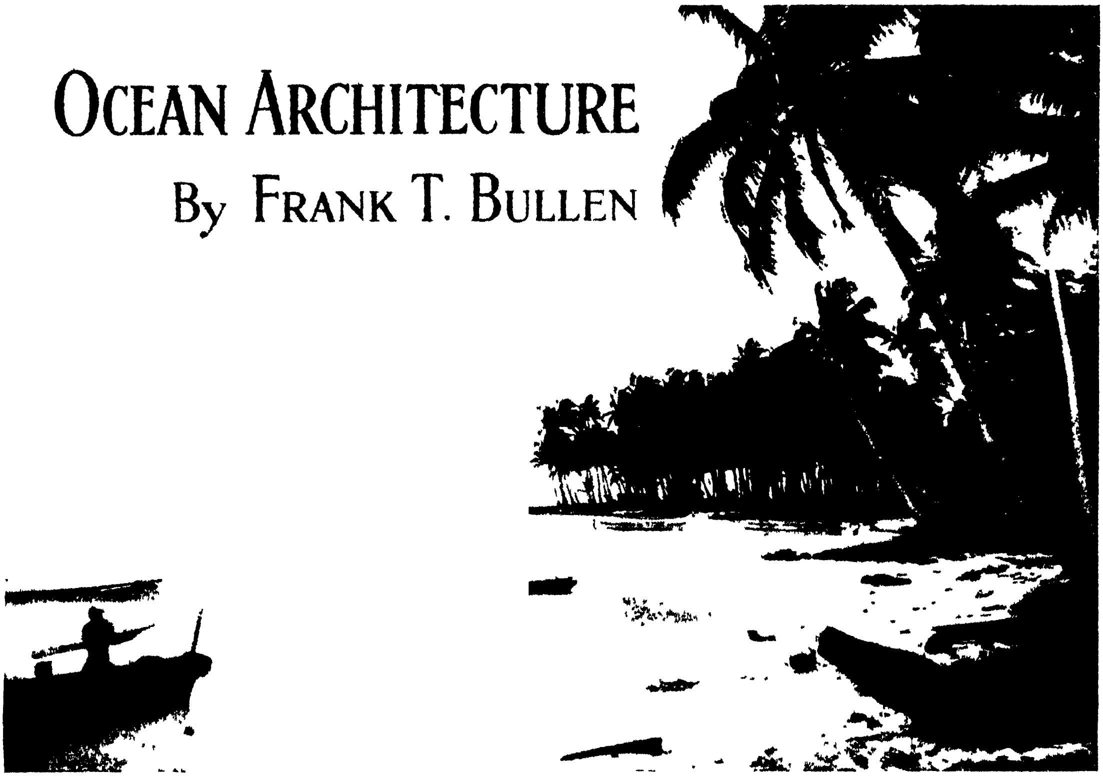
But the dene holes proper are very different, and still enfold problems and mysteries that are likely to remain long unsolved. What romantic histories also must be associated with them! Who will ever tell the whole story of the horse and man, arrayed in costume and harness of the early Georgian period, whose skeletons were found by the explorers in the dene holes at Hangman's Wood? Most of them are regular cemeteries of bones, those of wild animals that have fallen down and marked the walls in all directions with their desperate efforts to escape, and those of sheep and oxen, horses, dogs, and swine. In one we came across many scores of horse-collars in a good state of preservation. Old lanterns, Dutch bottles, and multifarious relics of the smuggling fraternity are mixed up with the usual conglomeration of articles usually found in a rubbish tip—crockery, ironmongery, and, once at least, several tons of pungent onions; but nothing that enables one decisively to fix the date of the original making.

Still, the dene holes provide good sport to the athletic type of explorer, whether he climbs down in the comparative luxury of a rope ladder or simply puts his feet and arms into the holes cut by the original excavators, and clambers down with the aid of a life-line; and who knows when some casual find may set the whole controversy at rest?

Emerging from One of the Galleries into the Central Chamber

OCEAN ARCHITECTURE

By FRANK T. BULLEN



The Fruit of the Labour of Madrepores and Millepores

The wonderful island foundations to be met with everywhere in certain tropical seas are constructed instinctively, planlessly and objectlessly, as far as we can tell, by minute coral builders

How Wind and Wave, Madrepore and Millepore, Toil Unceasingly to Alter the Configuration of the Shore

IMMENSITY is the key-note of this subject, not merely in point of size of the edifices constructed by the ocean, but in range and detail. So much is this so, that it may well be doubted whether any writings upon the subject, however voluminous, can do more than merely dally with its fringe. Yet it falls quite naturally into two divisions: the first dealing with the actual work done by the combined powers of wind and wave; the second with those amazing edifices erected beneath the ocean by the ceaseless labour of madrepores and millepores, those minute coral builders whose function it is to construct instinctively—planless and objectless as far as we can tell—those wonderful island foundations that are everywhere to be met with in certain tropical seas.

With the first of these divisions of ocean architecture very great numbers of our population are familiar, as far as passing glimpses of them go. For the habit of travel, owing to increasing facilities, has now grown so greatly that only lethargy is any reason for remaining confined to one spot for a growing number of people, and if the traveller do but avail himself of a sea-trip, he can hardly fail to notice the marvellous work that the sea has done, although he may not realise that this work is never completed. Yet, although it may be frankly admitted that whoso knows by sight the aspects of our shores, however superficially, can never be called ignorant of the grandeur of old ocean's work, it remains true that in many remote and seldom-visited portions of the land many of the choicest specimens of that work look out for ever upon emptiness—humanity has nothing to do with their grand and awful loneliness.

Especially is this the case in those outlying islands, which are but the tops of submerged mountains, vast bastions of rock rising from the midst of never-resting waves, which, through the ages, have carved them into a multiplicity of fantastic shapes. As their contour is altered by your point of view as you sail past them, such shapes will continually recall some well-known castle, temple, or other splendid image to your mind, but before you have well focused its significance, the outline has gone, and another, not less striking, is presented to your wondering eyes.

Where all are wonderful, stately, and magnificent, it is not worth while to discriminate, yet perhaps the strangest of all specimens of this first order of marine architecture are to be found on shores composed of lava. That Plutonic rock seems to lend itself, in some grimly humorous fashion, to fantastic shaping. I know of nothing that can appeal to the imagination with greater force than to sail closely along a coast like that of Ascension, for instance, on a very fine day, and note what the sea has done and still is doing.

The general effect is that of death to all intruders. As the great glassy swell rolls sullenly shoreward, and meets with its ancient foe, it is easy to realise what must be the fate of any creation of man's that may be hurled against that barrier. Nor is man the only victim, for all the larger of the sea-people seem instinctively to

A Natural Archway at Zaimoku Island, Matsushima, Japan

Vast bastions of rock rise from the midst of never-resting waves, which, through the ages, have carved them into a variety of fantastic shapes

[illegible]

Haycock Island, Whitsunday Passage, Queensland

Photo Hibbott

An Extraordinary Submarine Forest

The retreat of the sea on the coast between Leasowe and Hoylake, in Cheshire, has revealed the remains of a submarine forest The presence of the forest is a proof that at one time that part of the coast must have been some distance inland realise the danger, too, and keep at a safe distance from those terrible writhen points and barriers.

The destructive power of the waves is well revealed around the English coast. In places the constant hammering of the sea has cut away so many millions of tons of tall chalk cliff that villages that were once inland are now beside the sea. Elsewhere, indeed, villages and meadows have been ruthlessly overrun by the tide, and, like old Lyonesse, are totally submerged beneath the waters. As the photograph shows, the retreat of the sea on the coast between Leasowe and Hoylake in Cheshire has recently revealed the remains of a forest—thus indicating that that portion of the sea-bottom was, within comparatively recent times, inland.

Temples of Coral

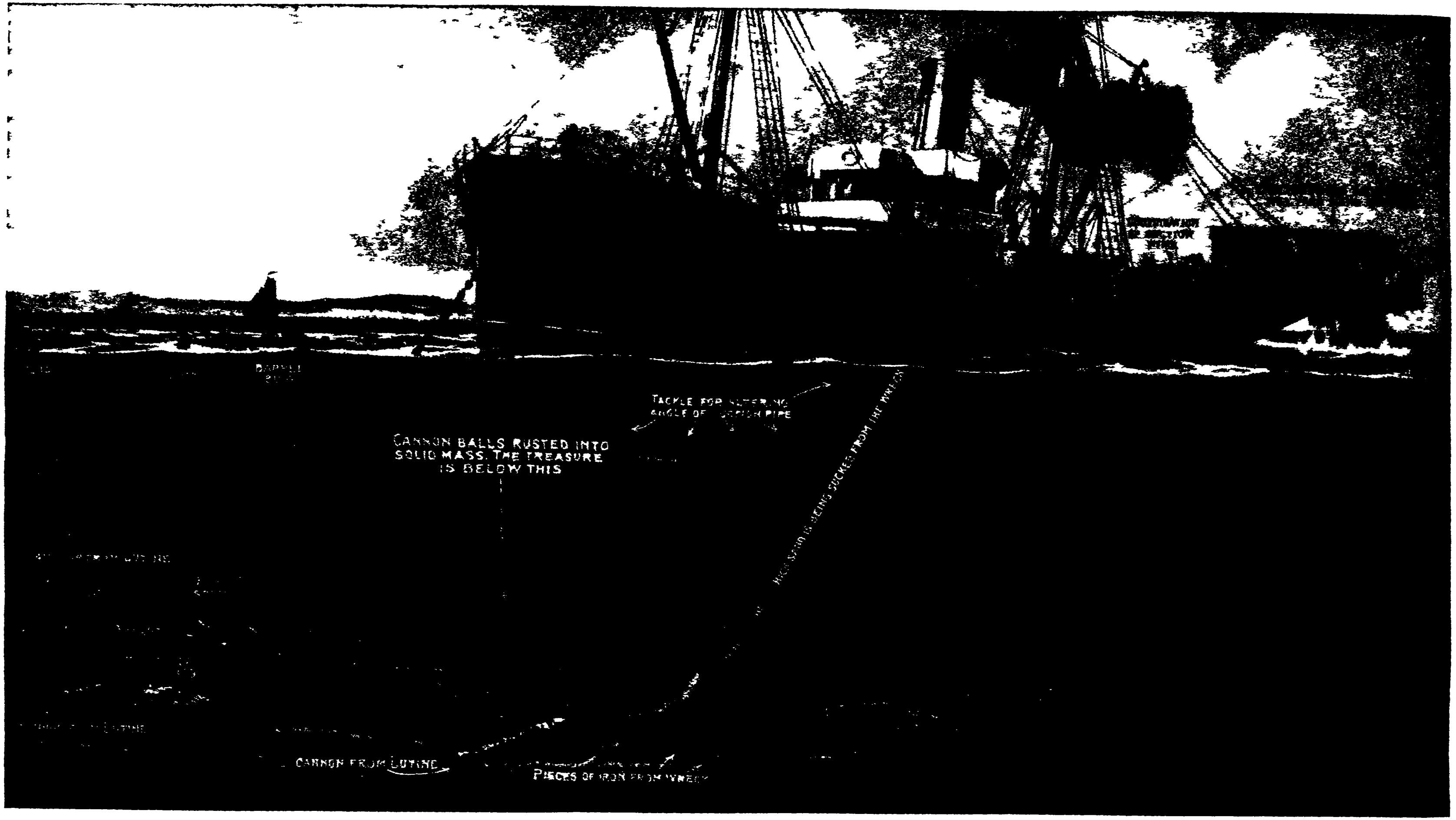
But if the first order of marine architecture has for its key-note grandeur, the second has as certainly the note of beauty. It would be entirely foreign to my purpose here to enter into the vexed questions of the depth at which coral reefs commence to grow, or their rate of growth, though that is a most fascinating study. I merely wish to point out the wonders and beauties of such reefs as the most exquisite specimens of marine architecture, and—to those who have the good fortune to visit the slumbrous seas where the coral builders thrive—the most easily accessible. Perhaps only a diver can enter fully into their beauties, as he roams through the glorious aisles and avenues of these submarine temples. Those much more simply equipped, however, though only able to peer down through the crystal water, may gaze entranced upon beauty and splendour far surpassing anything seen in the gorgeous dreams of an opium-eater.

In the great majority of places where coral reefs abound, though the seaward side may be inaccessible by reason of the tremendous impact of the ocean swell even in the finest imaginable weather, there is a sheltered side where the water is often as smooth and as level as a sheet of glass. In such places it is possible to lie flat on the reef edge, or to hang over the side of a boat, and study the wonderful structures below in all their elaborate tracery and splendour of colour and, so gazing, to forget the upper world. The beholder sees a living series of colonnades, aisles, domes, courts and esplanades; while, interspersed, are forests of the most fantastic, yet delicately lovely, trees of stone. In and out among these living labyrinths glide the inhabitants, which, in form and colour, match their surroundings, for in shape and tint they may challenge all animated nature to surpass them. So with the beds and parterres of sea flowers, each of which is an animal, though in beauty of colour and shape rivalling the loveliest hot-house blossoms.

Animal life is the central fact of all this wondrous scene. The mighty masses of architectural glory, the strange forests, whose branches and leaves never wane, are all alive and growing continually until they reach the surface. In countless minute cells madrepore and millepore toil out their tiny lives to add just one microscopic fragment to the stupendous edifices they inhabit, to abstract from the all-pervading sea just that infinitesimal particle of material which they need, in order to add their quotum to the vast and never-completed whole.

Unceasing Labour

It is wholesome, if disciplinary, to remember that when the erection reaches the surface of the sea, and enters upon its career of usefulness to mankind, it loses all its beauty, and becomes, in time, of course, just a patch of sand wherein the earth plants may take root and grow. Meanwhile, beneath the inscrutable waters, the work goes on as silently and surely as does the work of the stars above us, all part of the inevitable doing of the Great Architect of the Universe.


TACKLE FOR ALTERING ANGLE OF SUCTION PIPE
CANNON BALLS RUSTED INTO SOLID MASS. THE TREASURE IS BELOW THIS
SAND IS BEING SUCKED FROM THE WRECK
CANNON FROM LUTINE
PIECES OF IRON FROM WRECK

Treasure-Seeking by Suction

(Drawn by H W Koekkoek)

The illustration shows the methods employed by the National Salvage Association steamer *Lyons* to recover treasure from the British frigate *Lutine*, which went to the bottom off the entrance to the *Zuyder Zee*, in October, 1799. The 36 feet of sand which covered the *Lutine* were sucked away by the great suction pump

IV.—In the Depths: Artificial

The Wonders of Salvage

The Wonderful Means by which Ships and Treasure are Saved from the Hungry Sea

By HORACE C. DAVIS

As long as ships go to sea there will be accidents and disasters, and after these will come the salvors, whose duty it is to save the pockets of the underwriters by recovering the ship from a premature end. It is owing to them that many a staunch vessel still sails the waters, that once was a battered, abandoned mass of rusty, tangled wreckage, upon our barren seaboard.

To-day there are regular associations which exist and earn substantial dividends by salvage work. These companies build steamers exclusively for the rescue of luckless vessels that have gone ashore, or taken an unlucky dive below the surface, and have in their employ men who are experts at their hazardous calling.

The *modus operandi* is usually the same with most companies. Firstly, on arrival at the wreck, divers are sent down to survey the sunken ship, and thoroughly examine her position, the nature of her wounds, and to determine the best way of patching her. In comparatively shallow waters the work is considered quite easy, for the simple reason that centrifugal pumps can soon pump out the water after the holes are made secure, and thus the ship will become fairly buoyant and once more be drawn to the surface. But, though it sounds easy to mention patching, it is far from an easy job when working below the surface in a clumsy diver's suit.

A large undertaking, such as patching a rent over 6 ft. in diameter, is carried out with wonderful skill, though it possibly means that some dozens of holes have to be drilled in the skin of the ship to admit the bolts. In other cases timbers are placed inside the rent and long bolts employed, all ready prepared, to fit accurately into the outer timbers of the patch. When the divers have succeeded in getting the whole in position, with a well-bedded joint made ready, they are then able to screw up the outer fly-nuts and have the job quickly and neatly carried out with the minimum of exertion. In other cases the depth of the water, or the race of the currents, renders the work exceedingly difficult and dangerous to the men toiling below, and very often it is found that the divers can only remain for a few minutes at a time under water. When the work has to be carried out on an exposed coast, days,

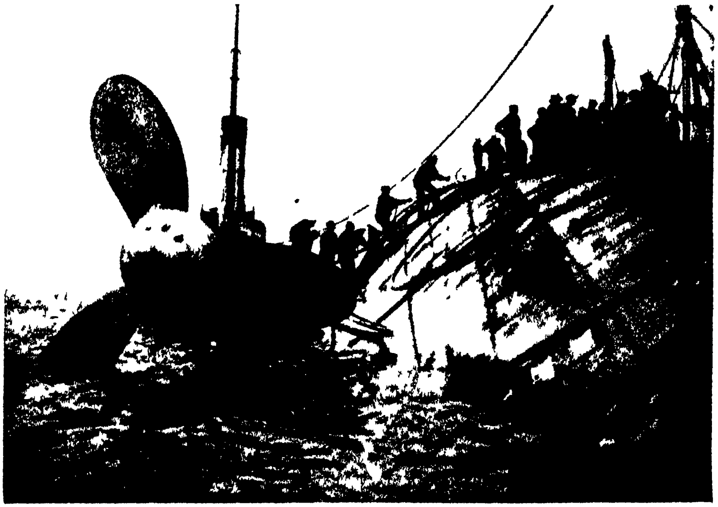


Photo A. Sell

Salvage Men Boarding the Wrecked H.M.S. "Gladiator" and even weeks, pass without the salvage craft being able to do a single thing.

Should the vessel be sunk in such a position that pumping is found to be impossible, another method is employed, which consists of lifting the wreck bodily. For this alternative it is first important to place a series of wire hawsers under the hull of the sunken ship, and when this laborious work is at last completed, huge metal cylinders are towed to the spot. These huge "camels," as they are called, are then filled with water and sunk alongside the ship, the hawsers are attached to the rings in the "camels," the armoured tubes from the salvage ship are connected, and the pontoons pumped out. These, thus becoming exceedingly buoyant, lift the wreck sufficiently for it to be gently towed into shallow water. There the work is again carried out, and at last the mass of tangled steel is sufficiently lifted to bring it into dock.

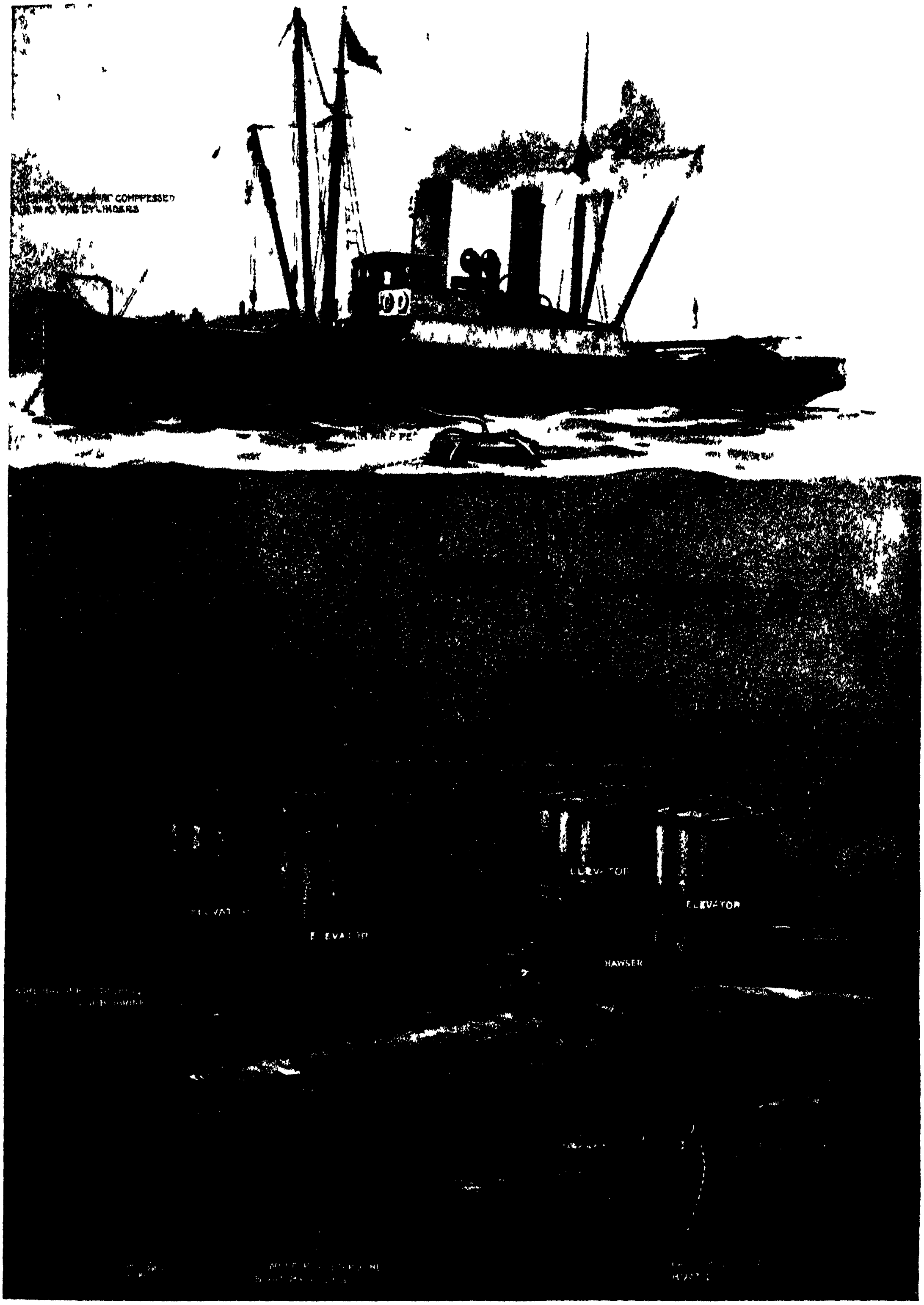
Another system consists of placing water-tight barrels in the hold, but this is only employed in the case of small wrecks. In addition to these devices, several inventions have recently been patented in which stout rubber and canvas ballonets are used, which can be packed in a small compass and sent below to the diver, who attaches them to the hull of the wreck, where the miniature balloons are then filled with air pumped down from the salvage steamer above, and are so endowed with an immense lifting power.

Photo K Sik

A Huge Steel "Camel" in Position Beside the Salved "Gladiator"

A, the point where the *Gladiator* was struck by the *St. Paul;* B, the hole where the *St. Paul's* nose penetrated the cruiser's skin; C, the collision mat which the crew tried to place in position before sinking

In addition to the patches already mentioned, there are other ingenious forms of leak stoppers in general use. Among these is the "Douglas," which consists of an apparatus not unlike an umbrella, which, when being used, is passed from inside the ship out through the hole. The "umbrella" is then opened and pressed securely against the side of the vessel. It is always essential that the small, sturdy salvage steamer must be well provided with batteries for firing high or low-tenison detonators,



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A Method of Raising a Sunken Submarine

(Drawn by H W Koekkoek)

As the illustration indicates, elevators, each consisting of nine waterproof canvas cylinders, are attached to hawsers already fixed to the wreck by divers The water in the elevators is then driven out and replaced by compressed air, which gives them the buoyancy needed to lift the sunken craft dynamite and tonite, pneumatic drills with air compressors for working them, and, in addition, a liberal supply of timber and wrought iron of all sorts and sizes.

For ships sunk in shallow water the centrifugal pump has been successfully employed in raising such enormous vessels as H.M.S. *Sultan*, sunk in the Mediterranean close to Malta, H.M.S. *Howe*, a 10,000-ton battleship that stranded on Pereiro reef, at the entrance to Ferrol on the coast of Spain, and also the steamship *Utopia*, sunk off Gibraltar.

The "Gladiator"

Of notable cases in which "camels" have been successfully employed, we have the salvage of the cruiser *Gladiator*, sunk by the American liner, *St. Paul*, off Yarmouth, Isle of Wight, during a terrible blizzard on April 25th, 1908. In addition to occasional bad weather the salvors, in this case, had to contend with a strong ebb tide, the current across the bow being often 8 knots at the ebb of the spring tides. Firstly, the guns and shields, weighing 15 tons apiece, were successfully salved, then the funnels, ventilators, davits, and other deck-fittings were removed by divers with the aid of pneumatic cutting tools. All the openings were made watertight—a long and laborious job. Next, two huge steel "camels," each 50 ft. long by 10 ft. in diameter (having about 100 tons buoyancy), and sheathed with wood as extra protection, with the ends protected by collision mats, were secured to the vessel for the purpose of increasing the buoyancy.

Next a number of ships were attached for towing, the pumps commenced to remove the water from the interior of the ship at the rate of 6,000 tons per hour; then the "camels" were blown dry. All working in perfect unison, the ship was righted from 70 to 7 degrees. Then it was decided to build cofferdams round the vessel, which made it possible to place more pumps on the boat deck of the wrecked vessel. Once more all the devices got to work together, and, in this way, with the pumps going at their fullest capacity, the *Gladiator* was towed into Portsmouth dockyard, a final triumph of one of the most difficult and dangerous salvage jobs ever undertaken.

Another notable undertaking, rendered increasingly dangerous by the position of the wreck, was the work connected with the loss of the battleship *Montagu*. She went ashore a bad wreck on Lundy Island, which is very exposed to all the westerly gales that sweep in from the Altantic. Notwithstanding her exposed position, the salvors succeeded in removing her heavy artillery and most of her valuable fittings. In connection with their huge undertaking they had to carry out some formidable engineering works, the most prominent being the erection of a bridge from the dangerous cliff edge to the deck of the stricken ship

The "Suevic"

The raising of the liner *Suevic* was perhaps one of the most remarkable salvage jobs. She ran on the rocks and ultimately broke her back. This item, however, in no way daunted the salvage firm employed. The bows and stern were completely divided, the stern portion being salved. This was then placed in dry dock, filled with ballast to keep it in the desired position, and the dock duly filled. A new bow was then floated in, and, guided into the required position by huge balks of timber, riveted to the hull skin of the stern portion. In this way the two halves were correctly brought together and securely riveted in place, so that the wreck became a ship once more, not only stronger than she was before, but also larger, it having been decided before the salvage operations were completed to build a new piece into her, which lengthened her by several feet.

Of more recent deeds of salvage firms, the work connected with the P. and O. liners, *Oceana* and *Delhi*, proved to be jobs of a truly difficult nature. The former was sunk in collision off Eastbourne, and, though it was impossible to raise her owing to the depth of water, divers were able to go below and recover her valuable cargo of bar gold. In addition they secured a large proportion of the more valuable general cargo and the possessions of most of the passengers. The *Delhi* went ashore off the coast of Morocco on a "thick" night, owing to the master mistaking the lights. Notwithstanding the prevalence of heavy weather, and the difficult position of the wrecked vessel, the salvage work was successfully carried out, the boat being saved and brought back to England, where she was thoroughly overhauled and repaired, and is again carrying passengers and cargo to and from the distant East.

In addition to this professional salvage work carried out by companies well equipped for their work, there is rescue work of another kind. This does not deal with the dragging of wrecks from their resting place upon the sea bottom, or the working upon vessels jammed secure upon a barren coast—work aided by all the latest appliances that human brains have placed to hand—but refers to even more strenuous work, carried out by ordinary deep-sea ships that fall in with another vessel in trouble, perhaps with a lost propeller or damaged steering gear.

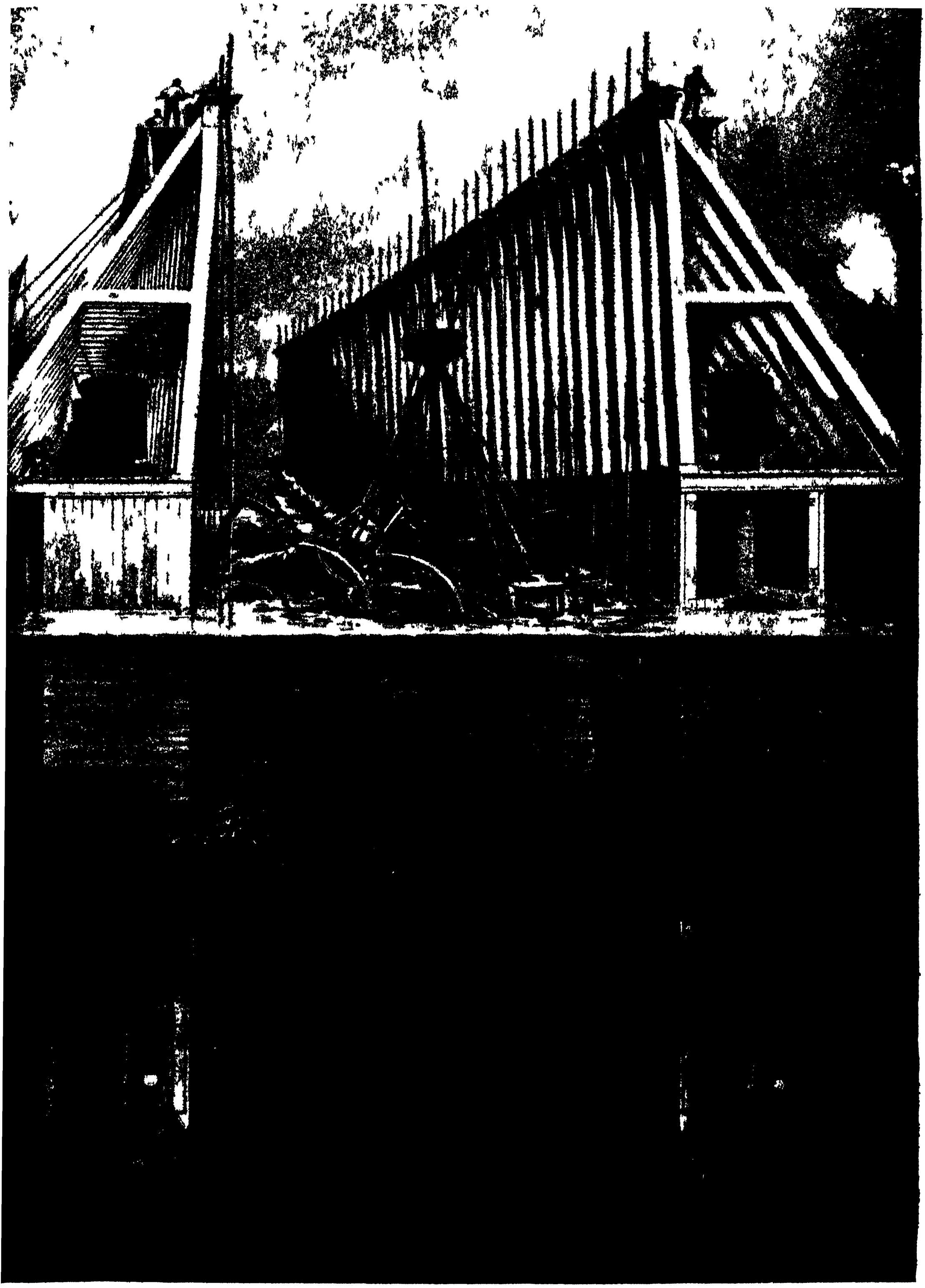
[illegible]

The Latest Invention for Submarine Salvage

The diver, who is in telephonic communication with the towing-boat, admits water to the tanks each side of his seat when he wishes his sledge to descend, and expels it by means of compressed air when he desires to rise to the surface

To the tramp steamer a plum of this description is luck indeed. The skippers of these mendicants of the sea will endanger life and limb, and wash their ships from end to end, to get a stout hawser aboard a disabled liner and bring her safe to the nearest port: for this means heavy compensation for all, from the cook's boy to the master.

Of recent notable instances of this type of salvage work we have many to choose from, perhaps one of the most remarkable being the help rendered the *Snowdon Grange* by the *Welchman* during terrific weather in the Atlantic. The former vessel was badly damaged about the stern by the force of the seas when she fell in with the



By courtesy of the Scientific American

A United States War Department Scheme for Raising a Sunken Ship

The ingenious scheme here illustrated was projected (though not ultimately adopted) for lifting the *Maine*, in Havana harbour It provided for the sinking of caissons between specially erected heavy pile wharves and the wreck, chains were then to be passed beneath the keel, from air-chamber to air-chamber, and the vessel lifted by powerful jacks. Ultimately a ring of caissons was established round the wreck and the water pumped out, thus exposing it

Welchman. For days the latter vessel stood by, ever striving to get her towing cable aboard the disabled ship. Twice this was accomplished, and twice the hawser snapped under the terrific strain of the two labouring ships. Then appeared the trawler *Salome* and tendered her aid, fastening herself astern of the *Snowdon Grange.* Then with the *Welchman* towing, and the *Salome* steering, the disabled ship fought her way through the mountainous seas and finally reached Queenstown.

The mere mention of the word " trawler " conjures up many such deeds of deep-sea salvage, and it has been said that these small but remarkably seaworthy vessels have a wonderful knack of finding out a disabled ship. During the awful March gales of 1914 no less than four trawlers were concerned in salvage work around our coasts, and so many lives have been saved by their efforts that they have rightly earned the title of " Life Savers and Ship Savers of the High Seas."

The Infinitely Hot

How Scientists Produce Extremely High Temperatures—The Manufacture by Nature's Own Recipe of Artificial Gems

By HOWARD TRIPP, M.A., Ph.D., F.C.S.

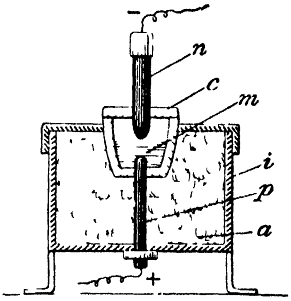
METHODS of producing high temperatures by the combustion of ordinary fuel-stuffs are as old as man himself. The temperatures necessary for performing such simple daily operations as burning and cooking—not always synonymous—are comparatively low and easy to obtain, but those which have been invented to satisfy the demands of advancing civilisation are phenomenal in their intensity, and have exacted the greatest ingenuity to discover and to apply to human needs.

Thanks to the labours of a long line of devoted scientists, we can to-day produce, at short notice, conditions of heat so appallingly intense that our imagination fails to grasp their magnitude, and in comparison with which the climate of Dante's Inferno would be colder than that of the regions of eternal snow.

The natural man has to rely upon his sense of feeling to enable him to distinguish between hot and cold; but this sense, though highly developed in certain people, can only be applied within very narrow limits. For accurate measurements the thermometer was designed, and some of those now in use are so sensitive that they can detect changes of temperature less than a two-hundredth part of a degree Fahrenheit. These instruments, however, altogether fail us when we have to determine very high and very low temperatures, because the liquids they contain either boil away or become solid like ice when exposed to the extremes of scientific hot and cold. High temperatures are measured by a " pyrometer," an instrument which depends upon the principle that the resistance to the passage of electricity of a metallic conductor increases with the temperature; therefore, by measuring the resistance the temperature can be inferred. Another method is to note the rise in temperature produced in a given amount of water or other liquid when a known weight of the heated object is suddenly plunged into it. In scientific work, temperature is always stated in degrees Centigrade, each of which is a little more than one half of a degree Fahrenheit; but in this article we shall adhere to the more familiar system, and to avoid undue prolixity all temperatures will be given in round numbers.

A simple way of "making a blaze"—which will appeal more especially to young readers—is to mix 3 parts of saltpetre, 1 part of sulphur, and 1 part of dried sawdust, and to apply a gas flame to the mixture placed in an iron or earthenware vessel. The heat produced—about 1,800° F.—is so great that small silver or copper coins can be easily melted.

One of the most useful means of producing a high temperature is the oxy-hydrogen blowpipe, a small metallic instrument which can be very easily handled. It consists of two concentric iron tubes, through the larger of which hydrogen is supplied, and through the smaller, oxygen. The hydrogen is first turned on and lighted at the end, and when the oxygen is passed in the two gases meet at the same point and burn furiously. The average temperature produced by this flame is 3,600° F., and the highest ever registered with it is 4,000° F. It is sufficiently hot to melt platinum and to boil silver, and when a cylinder of lime is heated in it, the well-known limelight is produced. In recent years this source of heat has been applied to the manufacture of "silica ware." Silica is a kind of quartz, and when melted behaves like glass, being readily blown into any desired shape; it also approaches glass in transparency, but differs from it in being able to withstand very sudden changes of temperature to an extraordinary degree. A silica vessel can be heated to a white heat and then plunged into cold water without, metaphorically speaking, a bone being broken. Acetylene gas is now much used with this blowpipe instead of hydrogen, and the oxy-acetylene flame, as it is called, is found very useful for melting through solid bars of metal, for welding steel tubes, etc. Even the modern representative of Bill Sykes employs it for melting through the walls of unsafe safes.



An Electric Furnace
c, crucible; *m*, material to be acted on; *p*, positive electrode; *n*, adjustable negative electrode; *i*, hollow metal jacket, packed with non-conducting material, *a*

We have already described, in "Silver from Clay" (p. 284), how temperatures up to 5,400° F. are produced with the aid of aluminium in the form of filings, a method which is technically known as the Thermite process.

At the present time the most important means of creating very high temperatures, both from the scientific and the industrial point of view, is the electric furnace. The successful invention and utilisation of this important apparatus is due to the ingenuity of the eminent French chemist, Professor Moissan, who is perhaps better known for his discovery of artificial diamonds. There are many different modifications of the original furnace used by him, but they may all be referred to two fundamental types: the arc furnace, and the resistance furnace.

The arc furnace, as the name implies, contains two carbon terminals between which a very powerful electric arc discharge takes place, exactly as it does in the electric arc lamp. The substance to be heated does not come in contact with the carbons, but its temperature is raised by the heat reflected from the walls of the surrounding chamber. The latter is usually made of pure carbon blocks lined on the outside with chalk or magnesia, and riveted together with iron bands. The resistance furnace is very similar, but with the important difference that there is no arc discharge; a single rod of carbon goes straight through the furnace, and is in direct contact with the material to be heated. In the arc furnace, which can produce higher temperatures than the resistance type, temperatures of from 3,600° to 6,300° F. are easily obtained for commercial purposes, and for scientific work one of 7,200° F. is produced without difficulty. The highest temperature said to have been reached with the electric furnace is over 12,000° F.

In his electric oven Moissan was able to convert carbon, one of the most refractory substances known, into a gas; and how he used it to obtain artificial diamonds is a story that we shall revert to presently.

Ph [illegible] *Clarke and Hyde*

The Hottest Flame in the World

Fusing aluminium with an acetylene oxygen torch

The electric furnace is no mere scientific curiosity; it is used industrially on a large scale for the manufacture of a number of valuable products, and the scope of its usefulness is being continually extended. Among the useful materials made with its aid are carbide, carborundum, graphite or black-lead, phosphorus, and alundum. The first of these is produced by heating freshly-burnt quicklime and carbon (in the form of anthracite coal, coke, or charcoal) in an arc furnace of a rotary form. All users of acetylene are aware that that gas has sometimes a very unpleasant smell. This is due to the charcoal used in its manufacture containing traces of phosphates, which give rise to phosphuretted hydrogen, an inflammable gas with a highly putrescent odour. Carborundum, the hardest artificial substance known to man, is made in a resistance furnace from ground quartz, coke, and a little sawdust and common salt. It is colourless when pure, but the commercial product is black, and has a strong iridescence. Its chief uses are as an abrasive, as a detector in wireless telegraphy, and in the manufacture of steel and of fire-bricks.

Over one half of the world's supply of phosphorus is now made by heating calcium phosphate (bone ash), sand, and carbon in the arc furnace. Alundum is the trade name for alumina as obtained in the electric furnace by fusing the mineral "bauxite," formerly regarded as infusible. Its usefulness for making tubes, crucibles, filters, etc., result from its great power of resisting heat and corrosion, its high conductivity for heat, and its mechanical strength and porosity.

So far, we have been dealing with temperatures obtainable by man, so fierce that they transcend any temperatures actually observed on or in the earth. Prodigious as they are, they pale into insignificance before those which probably exist in the immensity of space. Our own luminary can boast of a temperature of 11,200° F. Sir Norman Lockyer calculates that the surface temperature of the fixed stars is at least 54,000° F.; and to crown all, and to bring us to the apex of our theme—the infinitely hot—Arrhenius asks us to believe that some nebulæ attain the unspeakable temperature of 127,800,000° F.! Why, even one ounce of copper at that temperature would raise nearly two tons or 450 gals. of water from the freezing to the boiling point! At temperatures far below it, gold and platinum would boil away like steam, water would become more corrosive than the strongest acid, and substances generally, as we know them, would be unrecognisable. Our power of imagination deserts us when we try to imagine such transcendent conditions of heat; but by comparing one with another we may perhaps be able to gather a remote idea. If we call the temperature of our saltpetre mixture 1, then that of the oxy-hydrogen flame is 2, thermite 3, the sun 6, the electric furnace 5-7, fixed stars 30, and the nebulæ 71,000.

Transcendent Conditions

In passing, it should be pointed out that although we can be reasonably sure of the temperatures obtained on earth, those assigned to the heavenly bodies are more problematical, being based upon assumptions which cannot be verified. In other words, in dealing with terrestrial temperatures we are standing on the solid rock-bed of Fact, but in estimating those of celestial space we are taking flight on the wings of imagination into the misty but enchanting twilight of Hypothesis, or Belief.

The manufacture of valuable natural products from inexpensive materials has always been a prominent theme in the minds of experimental workers. From the early dawn of chemical science at the beginning of the Christian era, through the slowly developing daylight of the Middle Ages, down to the midday blaze of the Age of Science, man has ever sought to convert the cheap into the valuable, and the common into the rare. In 190 A.D. scientific activity was focused on the transmutation of base into noble metals; in 1900 A.D. chemists could point to a myriad of beautiful dyes and a host of artificial drugs, manufactured from coal tar, as the result of their successful labours. It must be confessed that these searchings and discoveries were not prompted solely by love of truth and discovery, for the innate love of material gain has seldom if ever been entirely absent.

Although the Philosopher's Stone of the alchemist has volatilised without leaving any residue, precious stones, as beautiful to behold as those produced by the "dove-tailing forces of Nature," have issued forth from the incandescent depths of the glowing crucible, and of the "burning fiery furnace."

In using the word "artificial" in connection with such products, it must be clearly understood that that word is not employed in the sense of "imitation" or "spurious"; an artificial gem is one identical in nature with that found in the earth, but produced by the hand of man.

Black Diamonds

The diamond consists of carbon, and is chemically identical with the charcoal that filters our water, with the graphite or "black-lead" we use in our pencils, and with the soot which accumulates in our chimneys. The difficulty of converting a non-crystallised into a crystallised form, e.g. charcoal into diamond, is due to the circumstances that carbon is exceedingly difficult to influence by heat, and most obstinate in refusing to dissolve in ordinary liquids. Molten iron is the only liquid which readily dissolves it, but when the melted mass is cooled, the carbon declines to separate out in the white vestment of virgin diamond, preferring the mournful garb of black-lead instead.

The secret of success lay in the application of enormous pressure on the carbon at the moment of its crystallisation. To Moissan, as we have noted, belongs the credit of the discovery. This investigator put a few ounces of iron in his electric arc furnace, melted it, and then quickly inserted some pure charcoal made from sugar. When the temperature was raised to 7,200° F., the lime of the furnace began to melt, and the iron commenced to boil away as vapour. The white hot crucible containing the iron and carbon, was taken out of the furnace, and the contents plunged into cold water. Torrents of steam arose from the latter, but the sudden cooling caused the outer layer of the fused mass to become solid, and to resist the expansion of the carbon as it tried to crystallise out. In this way an enormous pressure was caused to exist inside the mass.

When cold, the iron was dissolved away in spirits of salt, and the residue was found to consist of three parts: (*a*) a little graphite; (*b*) some fine twisted threads of brown carbon, similar to those found in the Canyon Diablo meteorites; and (*c*) a small quantity of a very dense mass which, after prolonged and tedious purification, was resolved into an opaque black portion—black diamond or carbonado, and a white transparent portion—the real precious gem. Some of these stones exploded on keeping, and thus paralleled the behaviour of some of the diamonds found at Kimberley.

[illegible]

A Temperature of 3,600° F.

The acetylene oxygen torch, which generates the almost incredible temperature given above, will free any metal and make it run in a second The illustration shows how metal objects, touched and partly melted by this torch, can be stuck to other pieces of metal as easily as paper is made adhesive with paste

Although these artificial gems were exceedingly small, the problem was solved; charcoal had been transmuted into white crystals which had the same shape, the same density, hardness, and optical properties as those formed by Nature.

Similar minute diamonds have been made in other ways. Sir William Crookes prepared some by exploding cordite and a little carbon in a closed steel cylinder, in which a temperature of 9,750° F. and a pressure of 50 tons to the square inch were produced. Chrustchoff made them in a similar way to Moissan, using silver instead of iron; Rousseau obtained them by heating carbide in the electric furnace. Lastly, diamonds have been found in steel! When a special kind of steel is cooled under intense hydraulic pressure, it gives up some of its carbon in the form of diamonds.

Though the largest artificial diamond which was obtained from steel only measured one-fiftieth of an inch across, there is no reason to doubt that in the fullness of time larger gems will issue forth at the command of Science.

The production of diamonds with the aid of iron has given rise to the theory that the natural stones were produced deep down in the bowels of the earth by crystallisation from molten iron. The discovery of diamonds in the well-known meteorites from Canyon Diablo in Arizona, where they are found embedded in a matrix of cosmic iron, has afforded startling evidence in favour of this contention.

Composition of Rubies

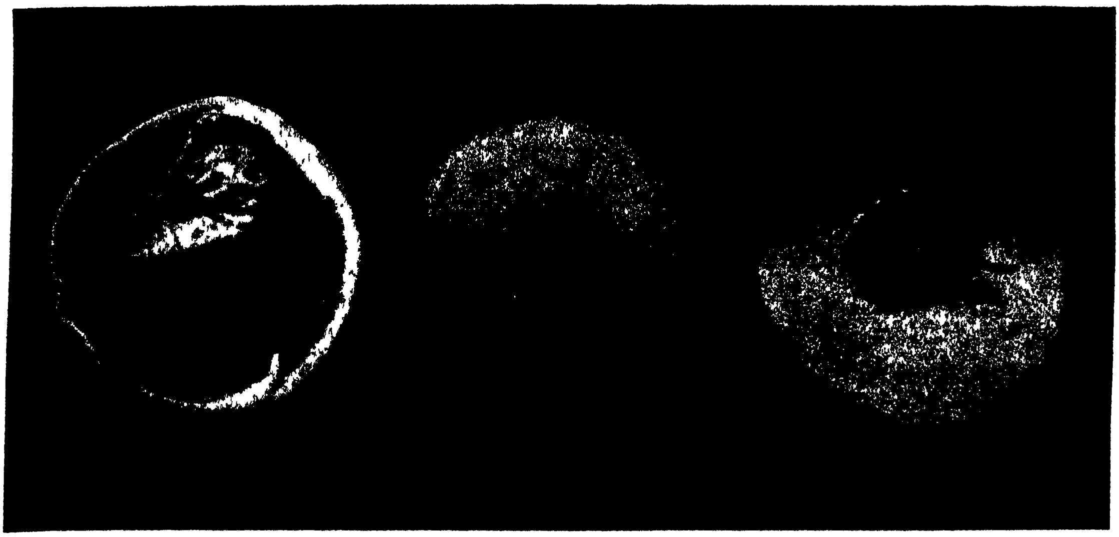
Natural rubies are classified into (*a*) the oriental or true ruby, and (*b*) the spinel or false ruby. Both are essentially the same, but the spinel is softer and contains impurities that are not found in its nobler sister. Each is composed of crystallised alumina (aluminium oxide), which is naturally white; it is the presence of a very minute trace of chromium that causes the roseate hue of the ruby.

The manufacture of rubies, sapphires, and other gems is based upon the admixture of traces of certain mineral colouring matters to pure alumina, melting the mixture and cystallising it by cooling. Microscopic rubies were discovered by Gaudin in 1837, and forty years later Frémy and Feil made stones sufficiently large to be cut.

Verneuil's Methods

The method which led to the production of artificial rubies and sapphires on a comparatively large scale was devised and published by Verneuil in 1904. His plan involved the use of a modified form of the oxy-hydrogen blowpipe, described above. Pure, finely powdered aluminium mixed with one-fortieth of its weight of chromic oxide is supplied by an automatic arrangement from a sieve of small mesh situated in the enlarged upper portion of the tube which conveys the oxygen. As the mixture falls through the intensely hot flame burning underneath, it melts and falls as small drops on to a pedestal, made of alumina, which can be accurately adjusted in any desired position. The molten droplets agglomerate on the pedestal, and when cooled down present the appearance of a small rounded pear. On the commercial scale a dozen blowpipes, all controlled by one man, are maintained in action at the same time, but the cheaper coal-gas is substituted for hydrogen. With such a plant a ten-carat stone can be built up in an hour, which, when cut and polished, resembles the best mineral rubies obtainable from Burma. For a long time it was found impossible to distinguish the manufactured from the natural gems, but in course of time it was discovered that the former possessed curved markings or striations, whereas the latter were marked with straight lines. Although such markings were only visible to the expert eye, the fact caused the price of the artificial gems to fall from £6 to 30s. per carat, and eventually it slumped to 5s. and less. By using a smaller amount of chromic oxide, pink stones—called Oriental topaz—are obtained, and when the chromium is replaced by titanium oxide, sapphires are produced.

The day is probably not far distant when all precious stones will be so constructed, in exact imitation of Nature.



Photos Harold Bastin

The Pea Weevil's Grub

1. The grub has eaten its way to the rind of the pea. 2. Shows the thin cover of skin left by the grub when it changes to the pupa. 3. The adult weevil making its escape, having pushed off the diaphanous cover

The Wonders of Instinct

By HAROLD BASTIN

Author of "Insects: Their Life Histories and Habits," &c.

THERE is nothing more mysterious and wonderful in the whole realm of Nature than what we call "instinct." The word is not easy to define, but its meaning may readily be rendered intelligible by a few concrete instances; and these may be most fittingly selected from the world of insect life, for insects are more dominated by instinct than any other class of animals. Take first the case of certain caterpillars that habitually spin their cocoons within a leaf of the tree upon which they feed, and before doing so are at pains to secure the leaf-stalk to its twig by means of a silk wrapping. As a result the leaf does not fall in the autumn, and the occupant of the cocoon is withheld from the dangers that would certainly beset it upon the ground. Clever caterpillar! So, at least, one is tempted to exclaim. But on second thought one perceives that the caterpillar does not merit this praise. Its parents died long before it was hatched from the egg, and in the nature of things it must be entirely ignorant as to the course of its own life-history. Thus, it does not guard against future risks because it is clever, but by virtue of certain inward promptings which it can neither ignore nor control. It is a very perfect automaton—a triumphant product of natural selection.

In the same category we must place the caterpillar of the Emperor moth, which furnishes the neck of its flask-shaped cocoon with an arrangement not unlike an inverted lobster-pot. The lobsters can enter a man-made trap, but not escape; the caterpillar's contrivance keeps out enemies and parasites, but yields to slight pressure from within, thus allowing the adult moth to creep forth when the time for its emergence arrives. A somewhat similar case is that of the pea weevil's grub, which in early youth takes up its position at the heart of a developing pea. The pea grows and the grub grows, and the latter eventually changes to a pupa within the pea. Before doing so, however, it carefully eats its way to the rind, leaving only a circular patch of thin skin between itself and the outer world. Through this diaphanous covering the adult weevil easily makes its escape. But how did the grub know that the pea, in drying, would become too hard for the weevil to gnaw an outlet for itself ? The answer is that the grub has no such knowledge. Its actions are purely instinctive.

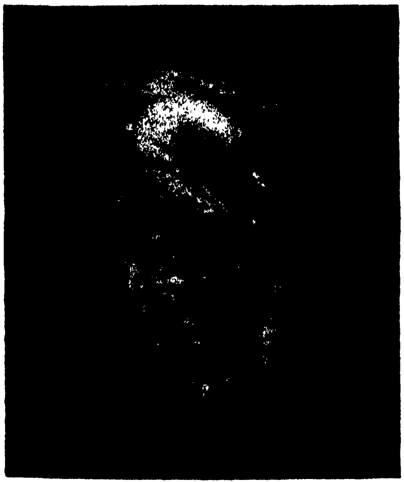
The Pea Weevil's Grub

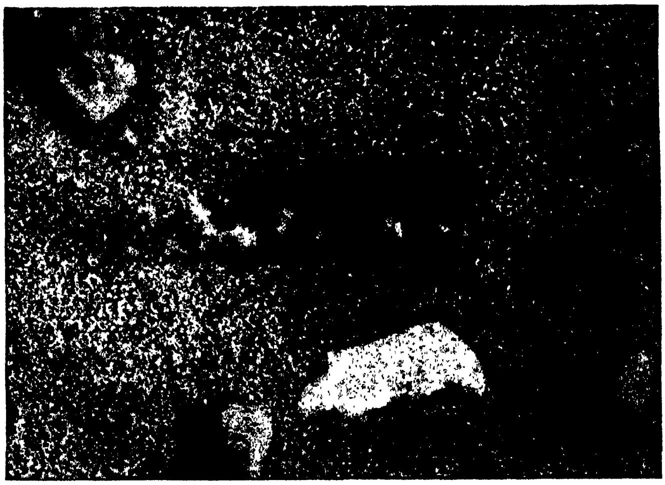
In no part of their behaviour do insects display more marvellous instincts than when they are preparing for the welfare of their young. Species that are normally clumsy and inactive become suddenly alert, skilful, and pertinacious—witness the scarab beetles and their kindred, which have attracted the notice of mankind from very early times. These insects knead stercoraceous matter into balls, and laboriously roll them to great distances in order to provision their subterranean nurseries. Moreover, the great French naturalist, J. H. Faber, has shown that they exercise the greatest discrimination—selecting the softer parts of the food, and placing it close to the egg, in order to provide a tempting first repast for the tiny grub when it hatches. No less impressive are the parental activities of the leaf-rolling beetles. One British species frequents the oak. Proceeding on definite lines, it cuts and creases about two-thirds of a leaf, lays an egg among the folds, and then deliberately rolls the severed portion into a compact bundle. That the insect does not learn by experiment or imitation is obvious. The blind grub that feeds within the bundle eventually falls to the ground, where it changes to a pupa, and lies dormant throughout the winter. Yet no sooner is it transformed into a perfect beetle than it flies to the oak, and begins to roll up leaves—exactly as its parents did a year previously. The leaf-cutting bees exhibit the same kind of untutored skill. As their name implies, they cut pieces from leaves and use them to make pockets, or cells, which they lay up in burrows. The leaf-fragments are either lozenge-shaped or circular, the former being employed to form the bottom and sides of the cell, the latter as covers. Numerous pieces go to the making of a single cell ; and, as an instance of the bee's perfection of workmanship, it may be said that cover-pieces are all so exactly circular that it has been found almost impossible to detect differences in their diameters, even when they have been tested by instruments capable of measuring accurately to the one-hundredth part of an inch. Nevertheless, these arts are not acquired ; they " come natural " to the insect in the most literal sense of the term. There can be no question of tradition, because this year's bees die long before their descendants appear on the scene.

Perhaps the most remarkable of all parental instincts are displayed by the solitary " digger " wasps. Here we see insects whose own appetites incline them to the sweets offered by flowers, engage in the chase and butchery because their offspring are carnivorous. In the vast majority of cases these wasps never know the young for whose welfare they make such careful provision. The so-called sand-loving wasps (*Ammophila*), for example, track down caterpillars and paralyse them by means of a deft sting thrust, each victim being dragged with much labour to a subterranean burrow that has been prepared in advance. Here, when the requisite number of caterpillars has been stored, the wasp lays her egg ; but she takes no further interest in the burrow or its contents when once her task is complete.

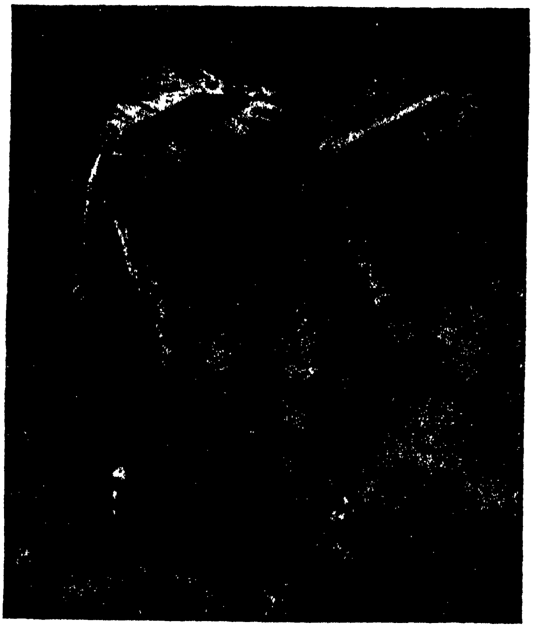
"Digger" Wasps

A marked feature of instinct, as opposed to intelligence, is that it shows very little





1. Leaf-cutting bee at work
2. Cells of the leaf-cutting bee packed into burrows in a rotten beam
3. Section of cell showing the grub wallowing in honey and pollen
4. Coprid beetle at work
5. A caterpillar which spins its cocoon in a leaf, first securing the leaf to the stem so that it shall not fall in autumn
6. *Ammophila* wasp dragging caterpillar to its burrow



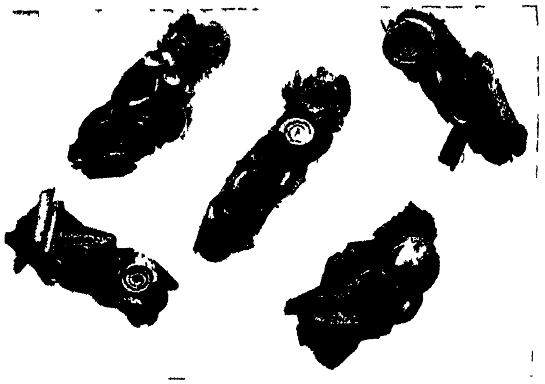
The Worker Bee

1. Showing tongue and wonderful hind legs
2. Hind legs, showing A. the currycombs on the inner aspect; B. the so-called pollen baskets on the outer aspect
3. Showing wax scales protruding

accommodation to circumstances which vary at all from the normal. Actions are performed in the same stereotyped fashion, no matter what the result. Faber has emphasised this by an amazing wealth of instances. He found, for example, by carefully removing one by one the victims brought by a spider-hunting wasp to her burrow, that the industrious parent had no "knowledge" of what she was doing. After the correct number of spiders had been brought home (and appropriated by the illustrious observer), the insect calmly deposited her egg in the empty cell, and closed it up as usual!

Certain modern students of animal life protest that the worker bee cannot rightly be regarded as an individual, but merely as a tiny cogwheel in a complex machine. This view is rendered plausible by the facts that the worker bee is unable to sustain a solitary existence, and incapable of reproduction—the latter faculty being vested in the queen-mother of the community. For the moment, however, we may ignore these nice distinctions, and speak of the worker bee in the abstract. In point of physical endowments she occupies an anomalous position. Disrespectful writers on natural history topics have even called her a "neuter," but her gender is truly feminine. Certainly she is emancipated from the cares of direct parentage, yet she retains all the native shrewdness of her sex, and has added thereto a vast fund of special ability. In one sense she is the drudge of the hive—architect, builder, sanitary expert, forager, foster-mother, and undertaker (not to mention a score of other offices) all rolled into one; but in another sense she reigns supreme, for the queen is queen only in name, and can do nothing without the sanction and goodwill of her subjects. The constitution of the hive has been termed an "organised anarchy."

How is the worker bee prepared for her multifarious duties? A full and complete answer to this question would make a



Caddis-worm Cases

bulky volume, so we must content ourselves with a brief summary. She begins life as a curved, white egg laid by the queen-mother in one of the waxen cells set apart as nurseries. In three days a small white grub issues from the egg. It is at once taken in hand by its elder sisters, the adult workers of the community. They feed it for the first three days upon predigested nourishment, called "chyle food," later upon honey, and finally upon honey and pollen mixed. But five days from the time of hatching the cell is filled right up with liquid honey and pollen, so that the grub lies in a bath of food; and when this has been done, the adult workers build a porous capping over the mouth of the cell. About twelve days later—twenty-one days from the time that the egg was laid—a brand-new worker bee emerges from the cell, fully equipped to take her part in the activities of the hive.

Part of the Bee Nursery
Showing grubs of various ages curled in their cells

She first acts as a nurse, carefully tending the rising generation of which she herself so recently formed a part. She receives nectar from the older workers, elaborates it in her chyle stomach, and thence regurgitates it for the benefit of her charges. But these are mere probational duties. In about a fortnight she flies abroad for the first time in search of nectar and pollen—an event which marks the attainment of her majority. She devotes little time to her own delectation. Most of the sweet juice that she sucks from the flowers goes no farther than her honey-sac—a part of her digestive apparatus that must not be confused with the chyle stomach mentioned above. In this receptacle the nectar undergoes chemical alteration; and when the bee, now returned to the hive, empties the contents of her sac into a cell, she mingles with them

Older Grubs at Different Stages

certain secretions, including a modicum of formic acid which probably serves as a preservative. But the brewing of the honey is not yet complete. Much of the water which it contains must be evaporated; and to this end the worker bees drive strong currents of air through the hive by rapidly vibrating their wings. This ventilating process is continued all night, fresh relays of fanners falling into the places of those that have accomplished their "spell."

Not the least interesting details of the worker bee's equipment are those which are employed for pollen gathering. Pollen is collected first amongst the hairs of the body, many of which are beautifully branched, or "feathered," so that they readily retain the minute grains. From her hairs the bee rakes together the pollen by means of certain wonderful curry-combs (shewn on p. 820) on her hind legs, and finally packs it for transport upon hair-rimmed depressions — the so-called "pollen-baskets"—of her hind shins. When the hive is reached the two masses are prised off by the aid of spines, which have their place upon the middle legs.

How Bees Make Wax

It would be possible greatly to extend our list of the worker bee's accomplishments, but we must limit ourselves to one more point—namely, her wax-making capability. Wax is generated by the bee in her own body, and issues in the form of scales—eight at a time—between the ventral plates of the abdomen. It is derived from honey, and is costly to produce—from sixteen to twenty pounds of honey yielding, it is said, only one pound of wax. Bees detailed for wax-making first gorge themselves with honey and then hang in a dense, heated festoon until the wax scales appear. The latter are subsequently removed from the abdomen, and chewed up with the bee's saliva—a process which renders the wax plastic. Finally, the wax is used to build the wonderful combs of cells in which bees rear their young and store their provisions.

Perhaps the most amazing point of all about the worker bee is the shortness of her life. We have seen how much care was lavished upon her infancy, and what marvellous potentialities lie hidden in her composition. Yet in two months, on an average, she dies—worn out, it is said, by excess of zeal and industry.

Insects that Wear Masks

Many insects wear masks in the sense that their identity is hidden under a deceptive cloak. The mask may be fabricated by the insect itself, or it may be an integral part of the creature's bodily structure. To the first category belong the cases of the caddis-worms, which dwell in ponds and streams. Physically a caddis-worm is weak, succulent and soft-skinned —an irresistible enticement to a passing fish, as every angler knows. But no sooner is it free from the eggshell than it begins to build. It has glands in its mouth which secrete a gummy fluid that hardens rapidly as it issues, forming a continuous silken thread. By means of this thread the insect binds together materials of various kinds, thus constructing the case in which the remainder of its aquatic existence is passed. At the tail-end of its body the caddis-worm carries a couple of strong hooks which serve to hold the case in position, so that when the insect pokes its head and legs out of its front door and begins to travel, it drags its dwelling along with it in much the same way that the snail drags its shell. Thus the caddis-worm can slip instantly into hiding when danger threatens; and as it spends most of its leisure in perfecting and enlarging its case, the latter is always a commodious and up-to-date affair. At the conclusion of its larval life, the insect closes up the case by a light web of silk spun at each end, changes to a pupa, and eventually becomes the winged caddis-fly which quits the water to lay its eggs.

Each kind, or species, of caddis-worm

constructs its case after a characteristic plan. One cuts up pieces of leaves and fixes them together with a crafty simulation of artless abandon that is entirely convincing. Another constructs its habitation of sand grains and small scraps of vegetable debris, and then, when the work seems to be complete, adds a finishing touch in the shape of a relatively huge piece of twig—thereby greatly enhancing the deceptive appearance of the whole contrivance. *Other caddis-worms (shown on p. 821)* display a passion for shells and small stones. When complete, their cases match exactly the drift of small shells and pebbles deposited by the eddy of a swiftly flowing stream. And it is precisely in such spots that these case-makers find their home.

Such facts suggest the assumption that your caddis-worm is a very artful fellow. But appearances are proverbially deceptive, and the probability is that the creature's mental equipment is of a low order. Indeed, we have little or no justification for opining more than this: That it is actuated by a general architectural instinct which it adapts with more or less success to the circumstances of its environment. Among the riff-raff that litters the bed of its ancestral pond or stream, it builds a case which is at once a snug home and a protective mask; but when removed from its accustomed surroundings it exhibits a profound lack of discrimination. For example, a caddis-worm deprived of its original case, will eagerly build another from fragments of coloured glass, gilt beads, and the like gaudy materials, if these come first to hand, being manifestly oblivious of the fact that it thereby renders itself glaringly conspicuous. So much for instinct!

Two Psychid Cases Fixed to the Bark of a Fir Tree

Many outdoor grubs and caterpillars make protective cases, those formed by some exotic species being so cumbersome that one wonders how their owners contrive to drag them about. In Britain we have three case-making caterpillars which belong to the remarkable group of Psychid moths. The largest species frequents certain moorland districts of Hampshire and Dorsetshire, and covers its case with small pieces of twig and heather. When about to pupate, the insect usually fixes its case to the bark of a fir tree, where it looks like a little wisp casually blown up and deposited by the wind. Perhaps the most remarkable detail in the life-history of these Psychid moths, however, is the fact that their females appear never to grow up. They remain grublike and inert, even when sexually mature, and never leave their cases, although the males pass through a normal metamorphosis, and appear in due season as winged moths, which fly rapidly about in search of their stay-at-home brides.

A NAVAL TARGET DURING BATTI

(Drawi

When the powders now in use in the Navy were first introduced, the spectacular side of battle-practice shifted fr it by the impact of the shells upon the sea. A target seen through glasses, after several big guns have been fi school of giga

PRACTICE BY BRITISH WARSHIPS

Norman Wilkinson)

the ship, enveloped in dense clouds of heavy white smoke, to the target, and the columns of water thrown up about in quick succession, is a remarkable sight, seemingly the centre of a series of terrific submarine explosions, or of a spouting whales

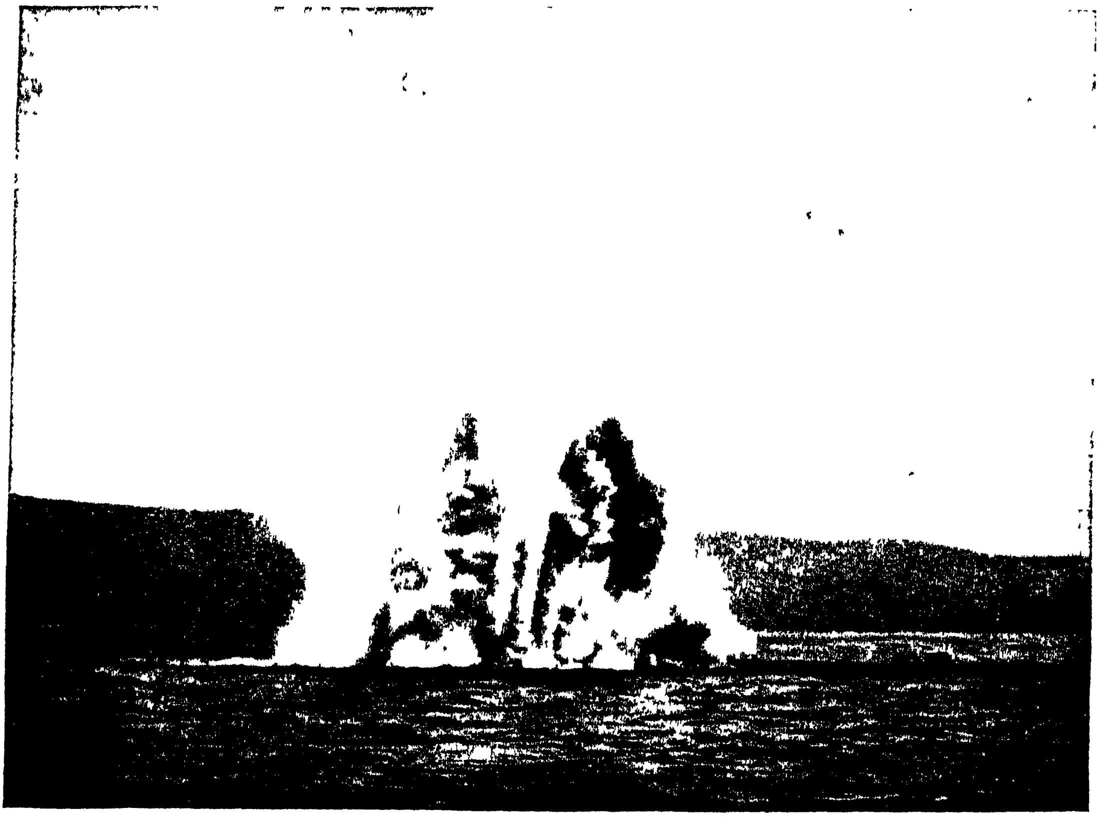


Photo by permission of Messrs. Siebe, Gorman & Co., Ltd.

The Surface Manifestation of an Explosive Charge Fired Under Water

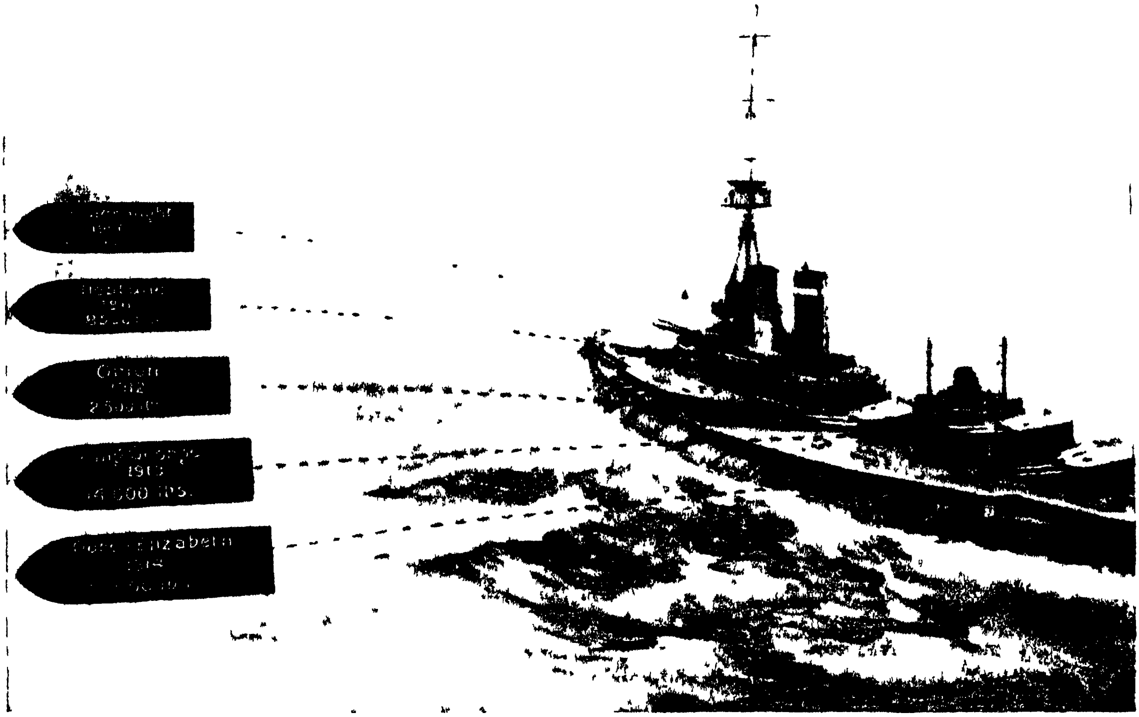
High Explosives

How Gun-cotton, Nitro-glycerine, Dynamite, Melinite, Lyddite and TNT are Employed

By E. B. MILTON

FOR many centuries the only powerful explosive known and used for warlike purposes was gunpowder, a mixture of sulphur, carbon, and saltpetre. With its aid, Constantinople defended herself for very many years against all her enemies, and the conquest of south-western Europe by the Arabs, in 711, was no doubt in part due to their employment of this means of offence and defence. At the outset gunpowder was known as Greek Fire, and was merely used to throw at the enemy like a modern hand-grenade, but it was made almost exactly as it is to-day. A most interesting fact is that its composition was kept a close secret by the Turks for from five to six hundred years; but for this the course of history might have been very different.

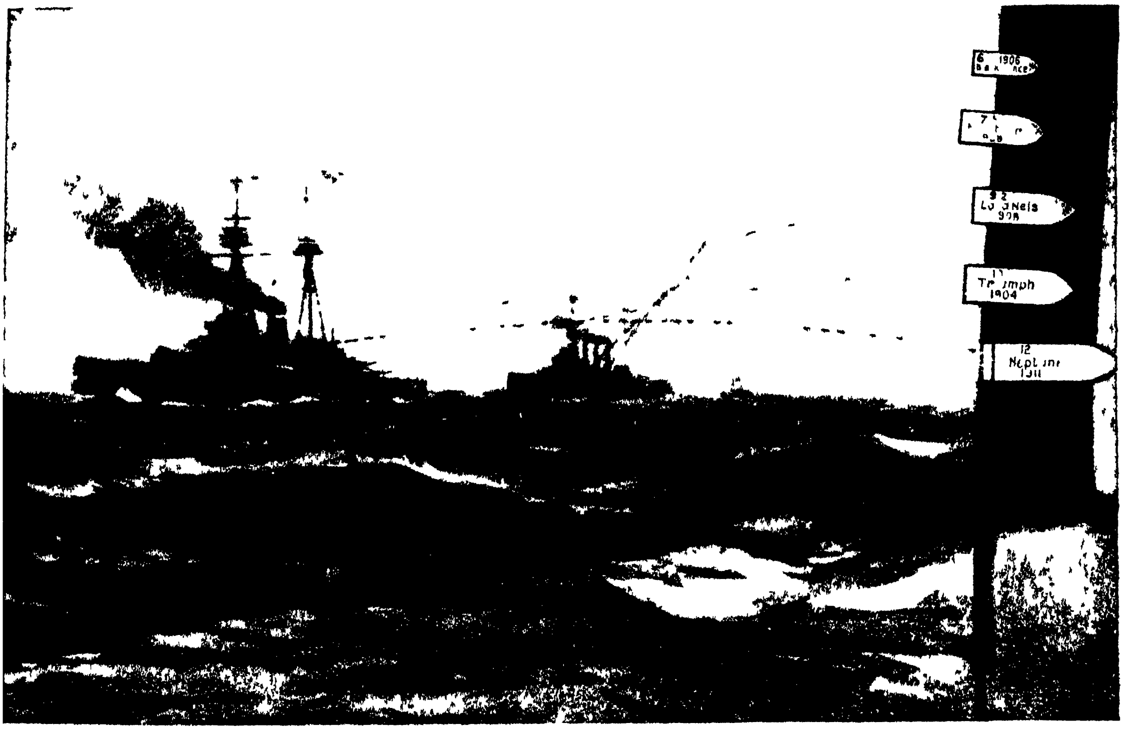
But this primitive pyrotechnic was a feeble weapon compared with its modern descendants, the high explosives. It was not until 1845 that gunpowder met its first serious rival in gun-cotton, or nitro-cellulose, a substance which soon came into general use, and has remained a constituent of the majority of smokeless powders ever since. When gunpowder is exploded it



Drawn by Cecil King

The Weight of Broadsides Fired by British Warships

The *Dreadnought*, with eight 12-inch guns, fires a total broadside of 6,800 lb.; the *Neptune*, with ten 12-inch guns, a broadside of 8,500 lb.; the *Orion*, with ten 13·5-inch guns, a broadside of 12,500 lb.; the *King George V.*, with ten 13·5-inch guns, a broadside of 14,000 lb.; and the *Queen Elizabeth*, with eight 15-inch guns, a broadside of 15,600 lb.



Drawn by Cecil King

The Penetrative Power of Big Guns on British Warships

This diagram shows the results of tests, made at 5,000 yards, against 36 inches of wrought iron. The penetration figures are from a Navy League table produces a number of solid products which are seen as smoke, but gun-cotton affords only colourless gases which are invisible. Cellulose is the organic matter which forms the basis of all vegetable products and of substances made from them (wood, cotton, silk, paper, etc.). To convert them into explosives they are treated with a mixture of nitric and sulphuric acids, technically called "nitro-acid." The process is simple, but nevertheless extraordinary care has to be taken, otherwise the finished product becomes a greater source of danger to those who use it than to those against whom its use is intended. The terrible disaster which befell the French Navy in 1911 will be in the memory of all. As shewn on p. 831, one of her proudest and mightiest engines of war, *the battleship La Liberté*, was completely wrecked, with the loss of many hundred lives, owing to the spontaneous explosion of some nitro-cellulose.

A Terrible Disaster

So much attention has now been devoted to the manufacture of this high explosive that not only can its serviceable qualities be relied upon after twelve to fifteen years' storage, but deteriorated material can be worked up again, and made as good as new at a very small cost. Gun-cotton and allied substances are prepared for service in various shapes and forms—tubes, cords, tablets, discs, and rods—each form exerting its own particular influence upon the rate of combustion of the explosive.

Very soon after the advent of gun-cotton, nitro-glycerine and dynamite made their appearance. The former is made by treating ordinary glycerine, a by-product of soap manufacture, with "nitro-acid," and as it is a liquid, and therefore not well suited for an explosive, it is mixed with a fine sandy material, "infusorial earth" (the remains of microscopic organisms), and in this way dynamite comes into being.

One of the most powerful of all high explosives is made by saturating gun-cotton with nitro-glycerine. It is known as "blasting gelatin," and, like dynamite, is chiefly used for peaceful industrial purposes, such as mining and tunnel-driving.

A strong impulse to the discovery of explosives more powerful than gunpowder was afforded by the theoretical conclusion that better results would be obtained by using projectiles of smaller diameter if they could be propelled with greater velocity. Accordingly, we find "melinite" discovered by the French, "lyddite" by the English, and "shimose" by the Japanese. But all these explosives are essentially the same, consisting of picric acid, a red solid made from carbolic acid, the disinfectant. The most up-to-date explosive for warlike purposes is Trinitrotoluol, which has very rapidly come into general use. This material (whose name might be mistaken for that of a Welsh village) is also known in different countries as trotyl, tolite, trilite, trinol, tritone, tritol, and also more familiarly as TNT. It has many advantages over its predecessors. It is perfectly stable, does not absorb water, and hence is equally effective under or above water; it is not sensitive to blow, shock, or fire, and is far more powerful in its effects. At the present time, gun-cotton, lyddite, and TNT are all used for filling shells, and are technically known as "bursters."

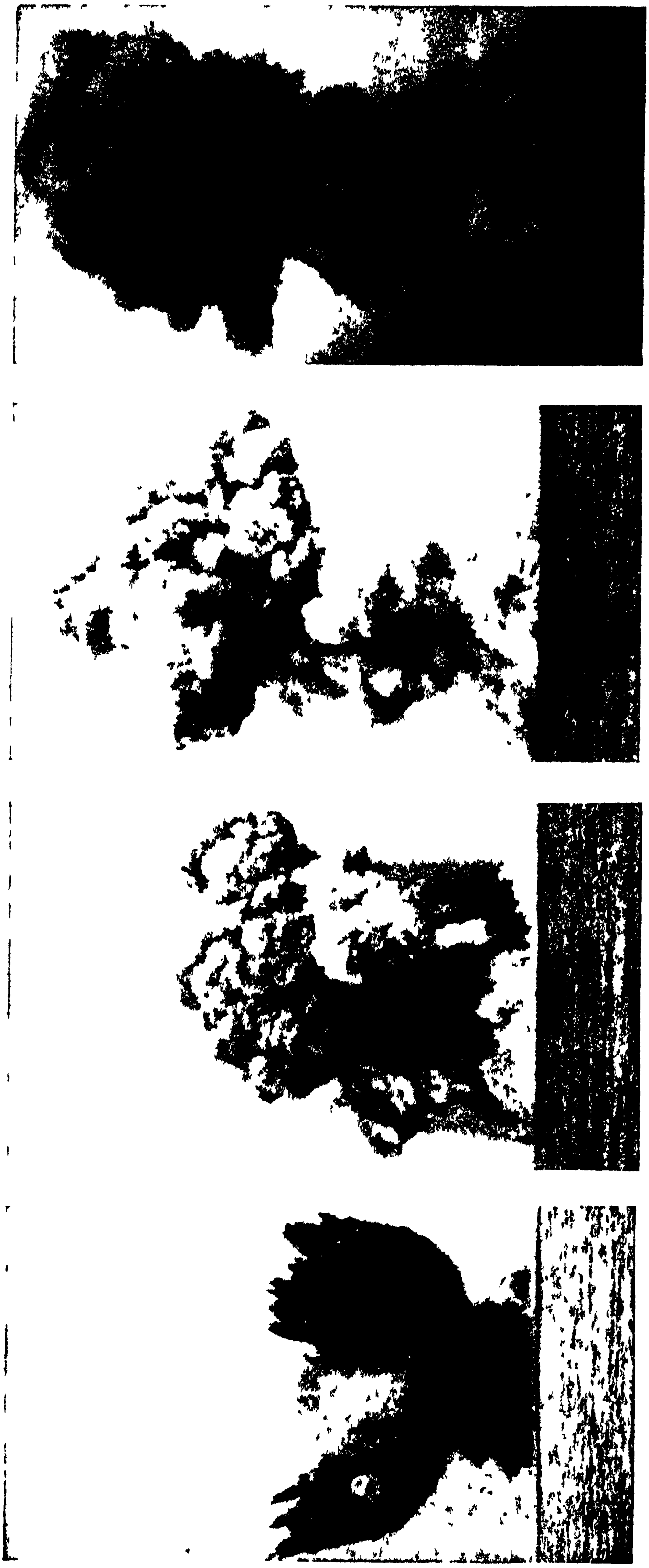
The "burster" is placed in the central portion of the shell, and in order that it may withstand the shock of impact on armour-plate, the outer casing of the shell is very thick and made of specially hardened steel, alloyed with one or other of the metals nickel, chromium, or vanadium. At the base is the complex mechanism called the "fuse," the function of which is to ignite the "burster." As the effect of a penetrating shell is greater than one which explodes on mere contact, its point is surrounded with a soft steel cap which supports and guides the hard point underneath, and so enables it to "bite" and penetrate the armour-plate. The effect of

Fuse and "Burster"

Photo by courtesy of Sir W. G. Armstrong Whitworth & Co. Ltd

A Remarkable Photograph Showing the Instant of Impact of a Shell Against a Ship's Armour

As the effect of a penetrating shell is greater than one which explodes on mere contact, its point is surrounded with a soft steel cap which supports and guides the hard point underneath, and so enables it to "bite" and penetrate the armour-plate



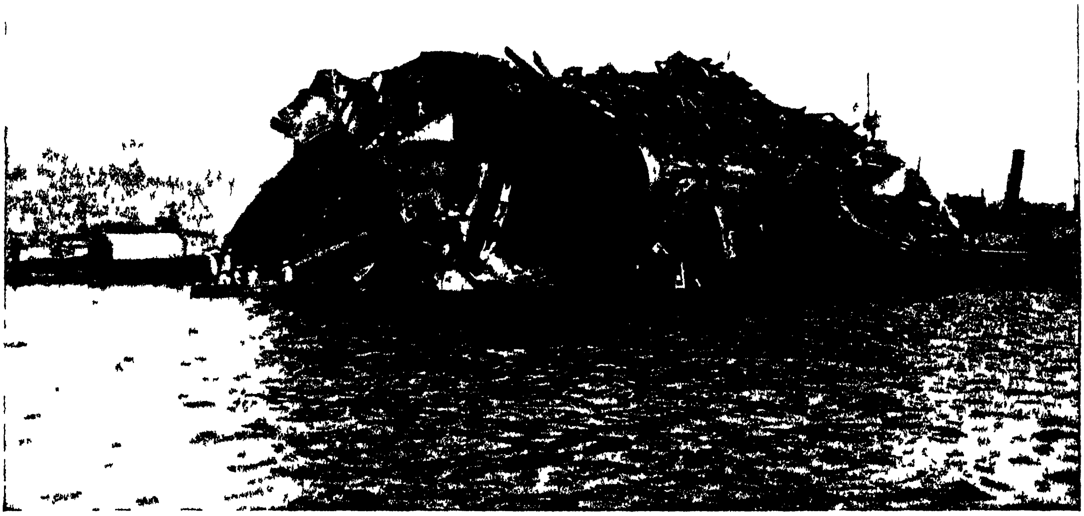
Photos Illustrations Bureau

Four Stages in the Intentional Blowing-up of the "Mystery," whose Cargo of Dynamite had become "tricky" through Exposure to Damp

a high-explosive shell on the armour-plate of a ship is exhibited in the picture of a wrecked and distorted 11½-inch plate shown on the opposite page.

Not only are high explosives used in the construction of shells; they are equally necessary for torpedoes and mines. The submarine mine is simply a charge of high explosive suitably encased, so that it either floats on or just below the surface. One type explodes on impact with a rigid moving body, like a ship; the other can be exploded by an electrical communication from a distance.

All explosions are due to the sudden liberation of an enormous volume of gas, which, being intensely heated, expands with terrific force. The material of the explosive undergoes a very rapid combustion, and at the same time, owing to the disturbance produced in the air, an air-wave is propagated which frequently travels and effects destruction at a considerable distance from the scene of the explosion. The progress from gunpowder to gun-cotton is well illustrated by their rates of burning. One pound of the former requires about a two-hundredth part of a second for its combustion, whilst the same weight of the latter "goes off" in a one-hundred-thousandth part of a second—i.e. five hundred times more quickly.



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All that was Left of the French Battleship "La Liberté," after a Nitro-cellulose Explosion

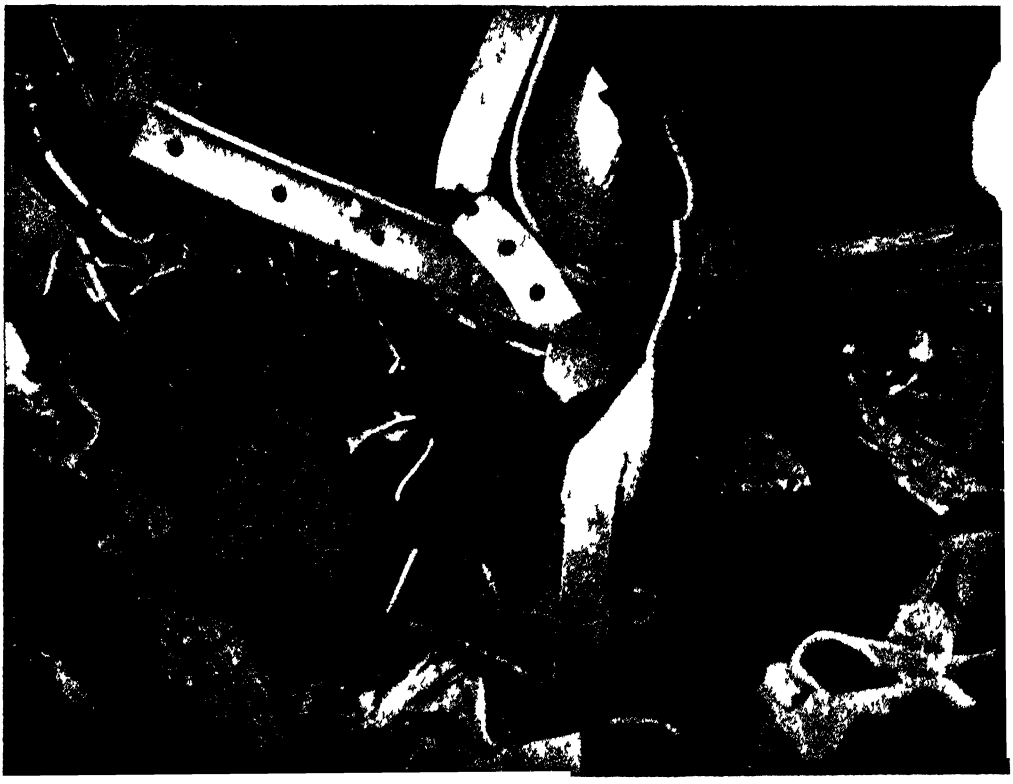


Photo by courtesy of "The Scientific American

The Back of a 11½-inch Armour-plate Wrecked and Distorted by a Bursting Shell

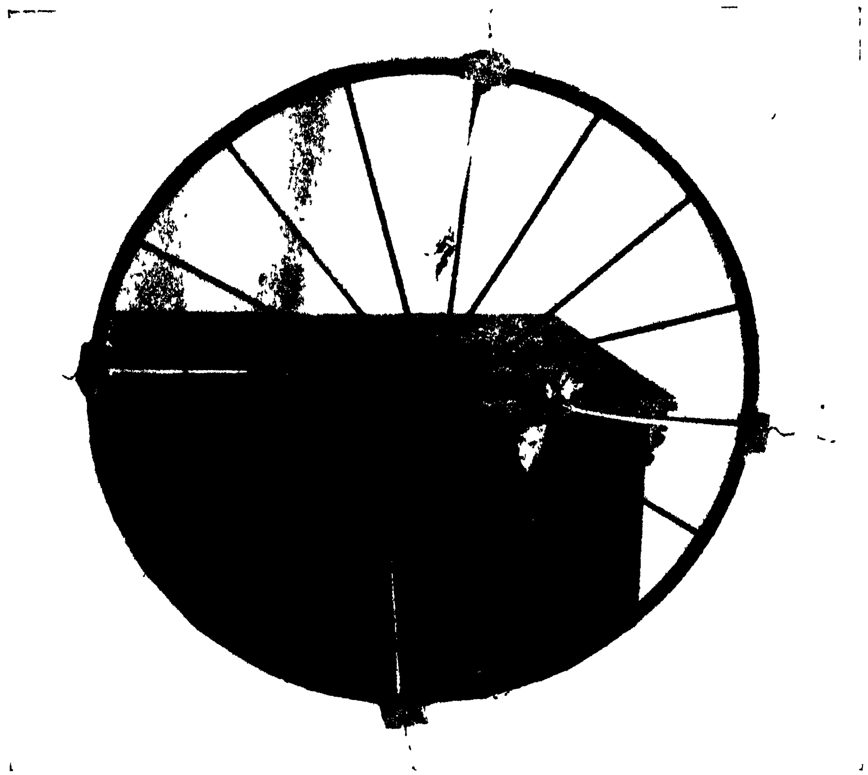
II.—In the Underworld: Natural

A Puzzle of the Ages

By S. LEONARD BASTIN

Author of "Wonders of Plant Life," &c.

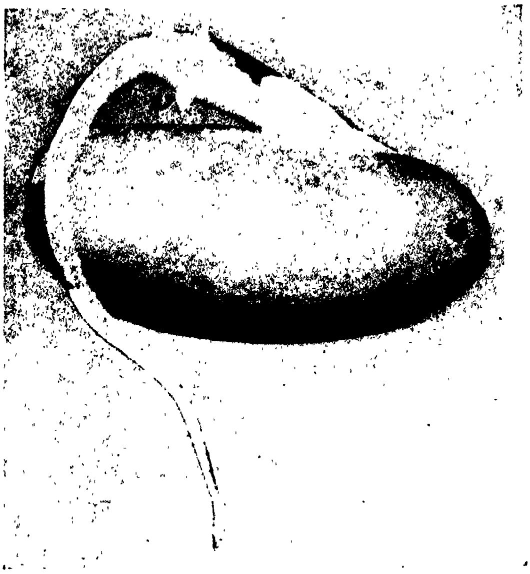
WITH the starting into life of the seed there occurs an event which the wisest man in the world cannot entirely explain. With a suitable amount of moisture and warmth a bean, for instance, will begin to germinate. First of all it increases in size, and then finally, through a small opening in its cover, the white tip of the root appears. This radicle, as the first root is called, always turns downwards. No matter how we may keep on changing the direction in which the root is pointing, it will always contrive to wriggle round so that it tends towards the earth. A bean stood upon end, so that its root is held out in horizontal fashion, is interesting to watch in this respect. In quite a short while it will be seen that the root tip begins to turn downwards, and by the next day the direction of growth will be entirely altered.



A Singular Experiment with Germinating Beans

Now this tendency is only to be observed in the case of the first root which the seed develops. The later roots which a plant produces will grow horizontally, and even upwards, if by these means they can get into a moister layer of soil. But the radicle of the seedling grows downwards, whatever the conditions may be. When seeds are sown in boxes with holes in the bottoms, the radicles go down through the holes away from the moisture of the soil out into the dry air, which eventually kills them. It is obvious that the roots do not go downward to avoid the light, for in this case they leave the darkness of the box. It is neither moisture nor darkness which the radicle of the seedlings desire.

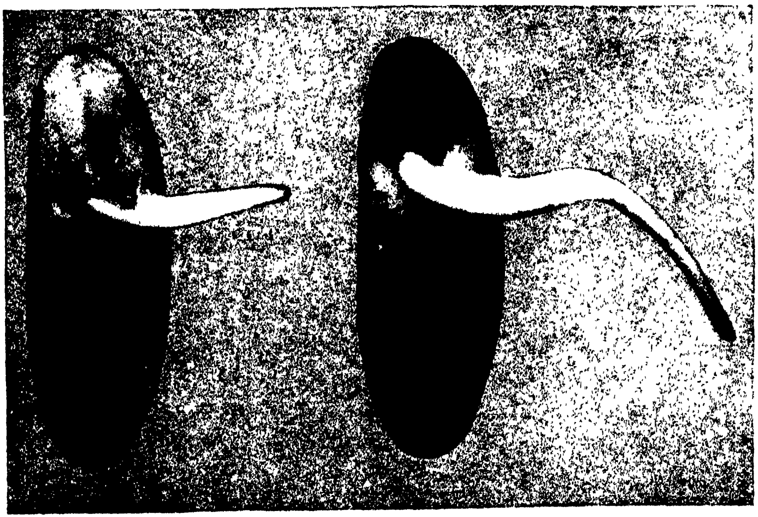
An interesting experiment has been carried out to prove that to an extent, at any



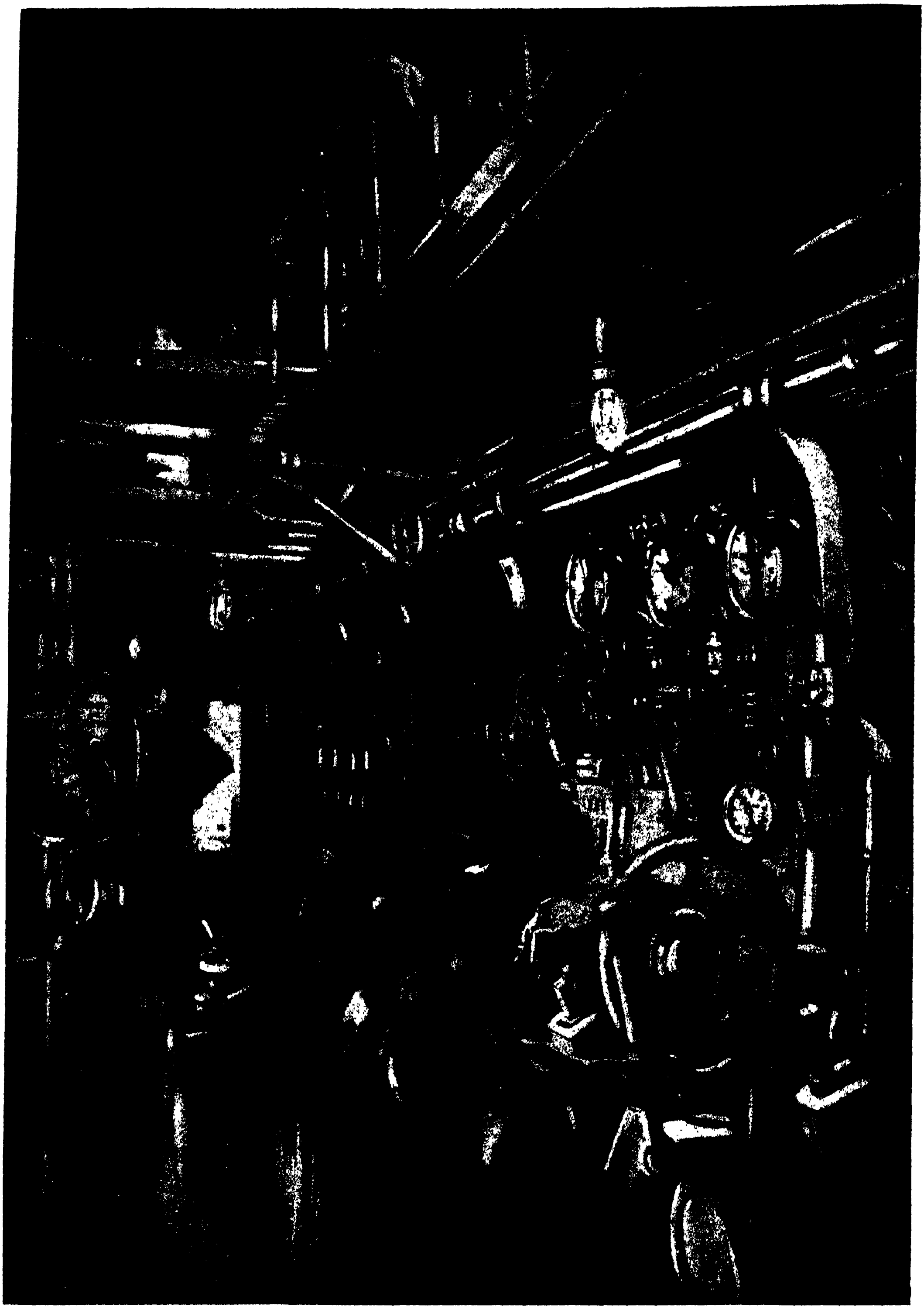
The root of a seedling will travel round a long way in order to get downwards in the end

rate, the roots of the seedlings are influenced by gravitation. Some germinating beans were placed on a wheel, the seeds being in damp moss so as to ensure a free growth. The wheel was kept in an upright position, and was revolved at a fairly rapid rate. Then a very singular thing happened, for the germinating seeds sent their radicles outwards away from the centre of the wheel. Evidently the direction of the growth of the roots was influenced by the centrifugal force of the moving wheel. This singular experiment has been carried out in a somewhat different form, in this case the wheel being in a horizontal position. Now when the wheel was revolved slowly the radicles of the seedlings followed an intermediate course. Still, to an extent, under the influence of gravitation they inclined downwards, although at the same time showing a tendency to grow outwards. When the wheel was revolved with great rapidity the radicles stretched out away from the centre of the wheel, being no longer responsive to gravitation.

Such experiments prove that the growth of the radicle is influenced by gravitation. But the matter cannot be dismissed with a mere mechanical explanation. We may say that the root of the seedling grows downwards in response to gravitation, but we must not overlook the fact that the stem of the little plant takes an opposite course. Modern science takes refuge in learned phrases about "organic tendencies" on the part of the radicle, but the simple fact is that we do not really know in the least what it is that makes the root of the seedling plunge downwards with such unerring accuracy.



This bean was placed (1) so that the root was in a horizontal position; next day (2) it had turned downwards toward the earth



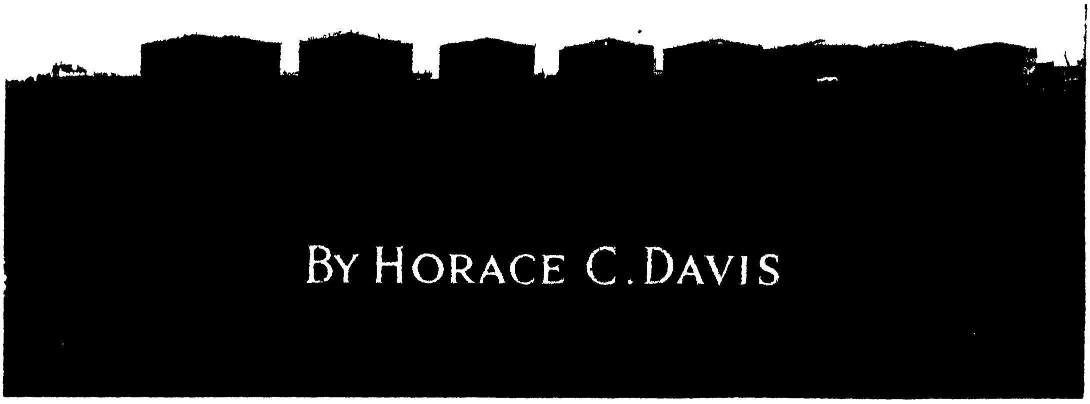
The Starboard Motor-engine of the Oil-driven "Selandia"

(*Drawn by Sotheby Pitcher*)

The engines have three "levels": the starting-gear, seen in the drawing, is on the lower level, and there are two galleries above. There are two engines, each of 1,500-i.h.p. The *Selandia* is 370 feet long between the perpendiculars, 53 feet in extreme breadth, and 30 feet in depth moulded to the upper deck. Her tanks, along the double bottom of the vessel, hold 900 tons of oil

III.—On the Sea : Artificial

SHIPS WITHOUT FUNNELS



By Horace C. Davis

Photo Porri, Grimsby

Oil Storage Reservoirs for the British Navy

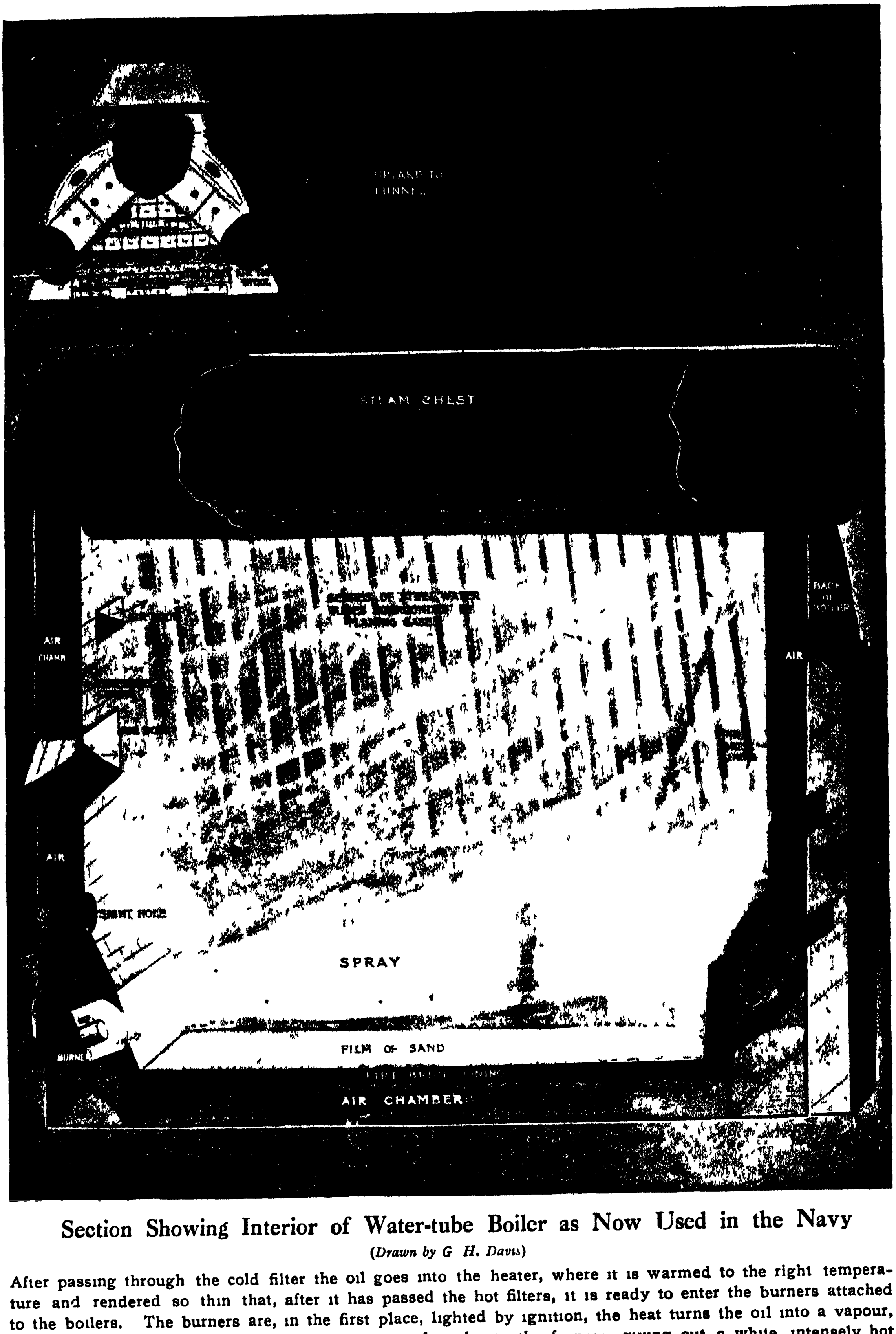
Concerning the Funnelless Ship—the Coming Era of the "Oiler"

JUST one hundred years after Bell's *Comet* (the first steamer to navigate the Clyde), had commenced the era of steam navigation, there was building, at the yard of Messrs. Barclay, Curle and Company, a ship in her way as epoch-making as Bell's puny steamer. This vessel was the *Jutlandia*, the first liner to be driven by oil engines and built in the United Kingdom.

Across the North Sea a Danish firm was building a sister-ship, and these two vessels, since they commenced to run, have been the subject of numerous highly technical articles; have been visited by hundreds of naval experts of different nationalities, and, having proved their worth and their popularity, they are being copied or improved upon by shipbuilders in various parts of the world. To-day, over a dozen fairly big passenger boats, to be driven by the internal-combustion engine, are under construction, and nearly a score of big commercial craft in addition, to say nothing of dozens of smaller vessels, such as coastal cargo boats, fishing craft, and various sailing ships which will use the oil engine as auxiliary power.

The future before this type of propulsion is immense, and there is no doubt that these engines will, in days to come, replace the steamer, just as in its day that vessel took the place of sailing clippers of a still earlier era.

The advantages in favour of the oil engine are as many as they are great. The space occupied is one-half that used by steam engines and boilers; the men to drive the *Jutlandia* are but eight in number, against the five engineers and twenty stokers required to work a *steam* ship of equal size and power; there are no hot furnaces to make the interior unbearable in the tropics; there are no steam mains running in every direction to set up corrosion and shorten the ship's life; there is no coaling—for the *Jutlandia* can carry enough oil in her tanks to take



Section Showing Interior of Water-tube Boiler as Now Used in the Navy

(*Drawn by G H. Davis*)

After passing through the cold filter the oil goes into the heater, where it is warmed to the right temperature and rendered so thin that, after it has passed the hot filters, it is ready to enter the burners attached to the boilers. The burners are, in the first place, lighted by ignition, the heat turns the oil into a vapour, and in this state, properly mixed with air, it is forced into the furnace, giving out a white, intensely hot flame. (Numerous unimportant fittings have been omitted) her to her destination (Siam) and back with ease—and, finally, the room occupied by the huge funnel uptakes can be utilised to better advantage, for in the *Jutlandia* class the mizzen-mast is constructed of hollow steel, and up this the engine exhaust can be taken, and the fumes discharged high in the air.

The two big eight-cylinder engines can generate over 2,500 horse-power, and are capable of driving the vessel at twelve knots. There are other oil engines for driving the dynamos to make necessary electricity for lighting, working the electric winches, and attending to a dozen other more or less important jobs, and the small boiler to drive the donkey-engine is the only steam used in the ship.

The Admiralty are just as alive to the coming of the oil-driven fighting-ship as the mercantile marine are to the coming of the big funnelless liner. At the present moment several oil-carriers for the British Fleet are building and will be fitted with internal-combustion engines. A destroyer is in hand with oil engines in conjunction with steam, and it is more than likely that at an early date we shall have experimental oil-propelled cruisers. For every one of our submarines (and we now have about eighty-five) the motor engine for surface work reigns supreme, and generates enough current to keep the electric motors going for driving the boat below the surface.

What it will mean to the designer of the fighting ship cannot at this moment be imagined. We may regard it as certain, however, that future Dreadnoughts with oil engines will have considerably less weight to carry, having no boiler or great coal bunkers, and this weight saved in the propulsive department can be utilised for fitting the ships with heavier armour and greater guns on the same displacement. Moreover, it will only be necessary to mount a single mast for carrying certain of the fire control instruments, wireless aërlons, and for signalling purposes; and the exhaust gases will be taken over the side and discharged into the water as now done in the submarines.

From the gunners' point of view the absence of superstructure and funnels will give him a greater arc of fire, so that he will be able to train his artillery practically in every direction. The vessels will also be instantly ready to proceed to sea at any moment, for there will be no waiting to get up the requisite head of steam; the awful business of "coaling ship" will be dispensed with for ever, and the oil will be pumped into the capacious tanks in a ship's double-bottom with ease and celerity.

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British Naval Oil-fuel Reservoirs

It may be asked why it is we have only been able to produce, up to the present, comparatively small ships with a speed little in excess of 12 to 15 knots. The explanation of this is the difficulty in obtaining an efficient and reliable engine, large enough to give the requisite horse-power to drive these big vessels at a speed that will allow them to compete successfully with the steam-driven craft.

The late Dr. Diesel, the greatest of all the oil-engine inventors for big ship propulsion, was forty years of age before he was able to make successful his now famous oil engine. Since then other clever brains have been at work, and the modern oil engine has been improved in a score of different ways. But we still more or less grope in the semi-darkness of discovery that obscures every new form of locomotion in its infancy. It is very probable that in a few short years the funnelless liner and the motor-driven war-vessel will be, in outward design, and with the types of oil engines in their machinery space, as different from the *Jutlandia* and *Selandia* of to-day, as is the modern 1,000-ton ocean-going destroyer from the first Yarrow-built little torpedo-boat that so surprised Queen Victoria by its speed and appearance.

Already, since the two first funnelless liners were built, we have, in so short a space of time, bridged enormous gaps in this search for an efficient oil-motor power-plant. No longer are the vast row of sixteen cylinders necessary, with their enormous number of auxiliary parts to attend to and keep in order. Engineers and inventors are using all their endeavours not only to give greater power, and, of course, greater speed, but—just as important—to give the motors greater simplicity and fewer working parts.

Very possibly most of us will live to witness the passing of the steam-propelled ship, as surely as the oil-engined vehicle has driven the horse from the streets of our big cities.

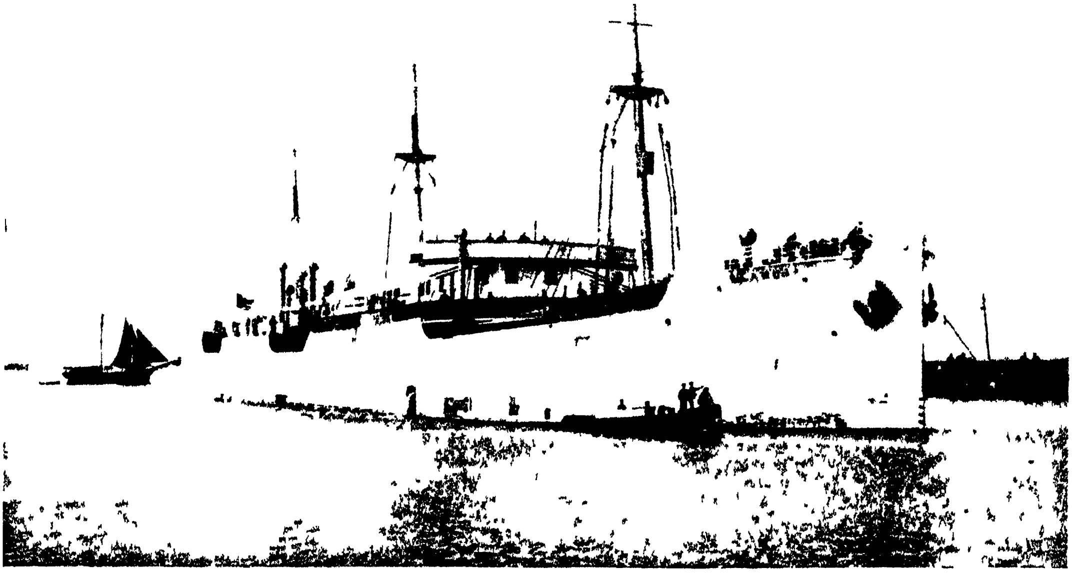
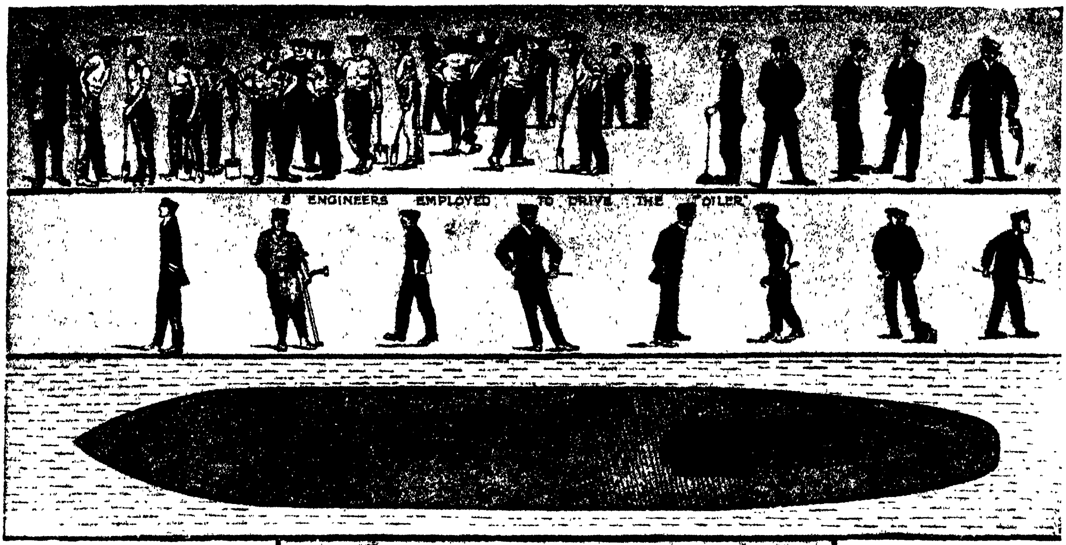
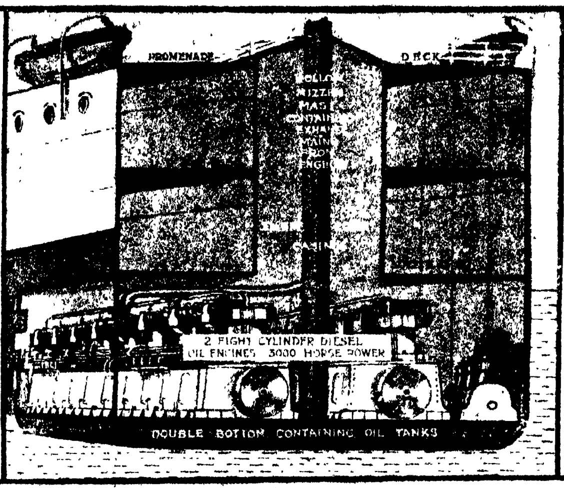


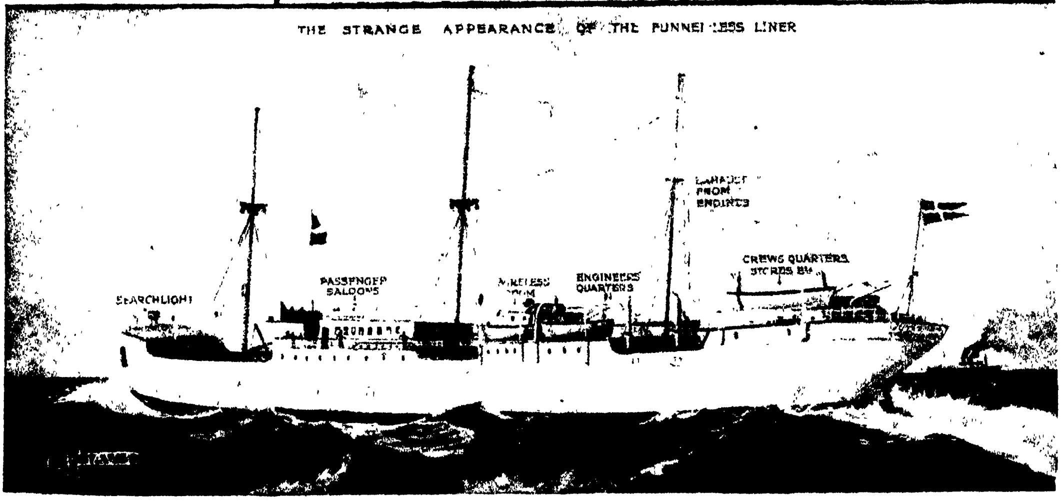
Photo supplied by Messrs. Burmeister and Wain, Copenhagen

The Oil-driven "Selandia"


8 ENGINEERS EMPLOYED TO DRIVE THE "OILER"

The uppermost portion of this page shows how in place of twenty-five engineers and stokers in a similar steam-driven vessel, only eight engineers will be required to drive the new oil vessel; the third section shows how small a space is occupied by the new oil engines as compared with those of a steamer. The centre view shows the arrangement of the oil engines and the method of getting rid of the exhaust. The lower view shows the curious headless appearance of the new ship when "sailing" at sea


PROMENADE DECK
2 EIGHT CYLINDER DIESEL OIL ENGINES 3000 HORSE POWER
DOUBLE BOTTOM CONTAINING OIL TANKS



The Coming of the Funnelless Liner

(Drawn by G. H. Davis)

How an all-round saving in space and personnel is effected by the new type of ship

IV.—In the Depths: Natural

The Migration of Fishes

By AUDREY PEASE

A Natural Tendency

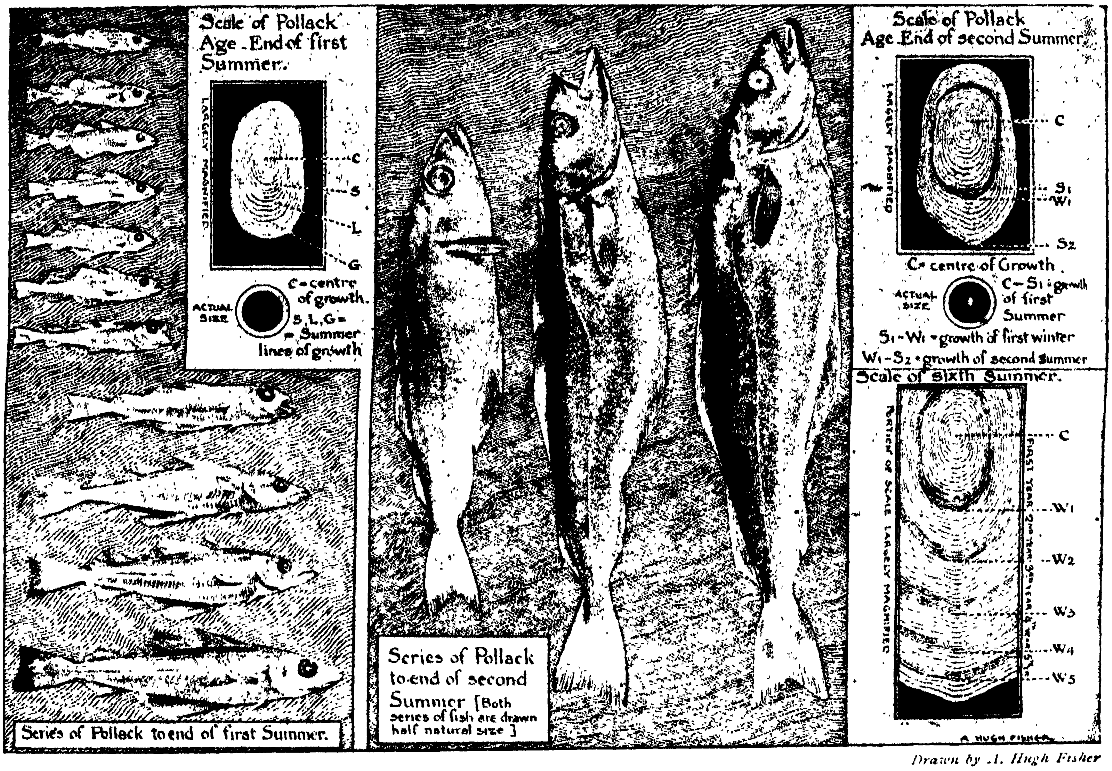
THE migrations of living things have for long ages attracted great attention—for it can be said that the migratory instinct is implanted in all animals, though only birds and fishes may be regarded as true migrants. All living organisms are capable of multiplying with great rapidity, and as the food supply in any one district is strictly limited, we find the natural tendency of every creature is to roam about in search of fresh hunting grounds. Such movements are irregular, and cannot be called true migrations, but the movements of birds and fishes are periodical and regular. One would be inclined to think that the fish's lot was a lucky one, and that he could explore at will the whole sea or ocean to which he belongs. But this is far from being the case, and the fish on his travels meets with quite as many impassable barriers as does the air-breathing animal. The temperature of the water is an important obstacle, and one which cannot be surmounted by many species; while depth forms a complete hindrance to shallow-living fish, the Atlantic proving to them as impassable as it is to, say, a fox. Of the movements of deep-sea fish nothing is known, nor does it seem likely that anything ever will be found out about the mysterious lives of these strange creatures of the deep. It is not probable, however, that any long distances are traversed by these fishes, because the conditions as to temperature and food supply must be very uniform throughout the deepest parts of the sea. This is clearly shown by the fact that the deep-sea fauna of different oceans resemble each other more closely than their less mysterious brothers, who pass their lives nearer the surface, where the sun's rays are able to penetrate. It is possible to discover something of the migrations of these fish, but even so our knowledge of this subject is very slight, and it is mostly of the fish round our own coasts that something is known.

Nearly all marine fishes are believed to migrate to a certain extent, at least those living in shallower waters. The movements of adult fishes depend on three causes or conditions—the breeding instinct, the need for food, and the season of the year. Nearly all fish have their customary breeding places, feeding grounds, summer and winter quarters, to which they resort at the respective seasons.

The Cause for Roaming

The chief cause for roaming is undoubtedly the necessity of finding a safe and suitable place for spawning, and as there is a considerable diversity in the eggs of fishes, both as to size and shape and also mode and place of deposition, it is not surprising that their migrations at the breeding season are very different. The eggs of some fish are heavy and sink at once to the bottom; many have various devices by which they become attached to rocks, stones, or empty shells; others adhere to one another in larger or smaller clumps. It is obvious that such fish must lay their eggs in shallow water and find a suitable bottom. Others, again, lay eggs which float on the surface, and are for this purpose light and buoyant and generally transparent; only marine fishes produce these pelagic eggs. After being laid, these minute eggs are left to their own fate, and the parents can know no more of their offspring. This is not the case with all eggs of the other kind, which lie on the bottom of the sea, for the parental instinct is often highly developed in fishes which lay this type of egg, and one finds numerous examples of nest building, and various ways by which the male protects the eggs. In the butter-fish of British seas the eggs are rolled into a rounded mass by the fish coiling its body about them, the parents alternately taking possession of their treasures. In many cases, when the eggs are attached to rocks or stones, the male is constantly in the vicinity and protects them from enemies, while he also serves to aerate them by keeping up a continual flow of water by the action of his fins. Many fish protect their eggs by burying them among loose stones, or even in the deserted shells of molluscs.

The members of the herring family, such as the sprat, the anchovy, the pilchard, the shads, and the herring itself, are mostly migratory to a certain extent, and the movements of the last mentioned have been much studied of late. The questions connected with the spawning periods and places of the herring form a subject of great interest both commercially and from the naturalist's point of view. These fish live in shoals and are pelagic in habit, spending their lives near the surface of the water except when spawning. Unlike other allied forms, the herring lays eggs which develop on the sea bottom, attached to stones and other fixed objects. It is now known that herrings spawn in winter, summer, and autumn, and the spawning periods differ considerably in various localities. The fish seem to have their own special spawning ground to which they return year after year, but apparently a particular spawning place is never used twice in the same season.


Scale of Pollack Age. End of first Summer.
Largely magnified
C
S
L
G
Actual size
C = centre of growth.
S, L, G = Summer lines of growth
Series of Pollack to end of first Summer.
Series of Pollack to end of second Summer [Both series of fish are drawn half natural size]
Scale of Pollack Age End of second Summer
Largely magnified
C
S1
W1
S2
C = centre of Growth.
Actual size
C–S1 = growth of first Summer
S1–W1 = growth of first winter
W1–S2 = growth of second summer
Scale of sixth Summer.
Portion of scale largely magnified
First year 2nd year 3rd year 4th 5th
C
W1
W2
W3
W4
W5
A. Hugh Fisher

Drawn by A. Hugh Fisher

How to Tell the Age of Pollack

Series of Pollack (*Gadus pollachus*) illustrating the annual growth of the species in the English Channel, and series of scales of pollack to illustrate a useful method of determining the age of the fish

Observers have come to the conclusion that the winter-breeding fish are of a different race to those which spawn in the summer, for these races are distinct in their habits, and frequent spawning beds of different character. The winter fish like brackish water and spawn near the coast, while the summer race prefer the more open sea, and although they approach the coast in the spawning season, they do not enter estuaries. The old theory of the movements of this mysterious fish was that its home was in the northern seas, from which annually a great southward migration took place, and this was the supposed reason for the fishing season being earlier at the northern parts of the East coast. This theory, however, does not account for the fact that ripe fish are found at every stage of their journey; they are caught in the spawning condition at Wick in July, and at Lowestoft in November. It is probable that, after spawning, those who escape the many lures of the fisherfolk, return from whence they came, to reappear the next season to renew breeding operations. There is good reason to believe that mature herrings do not remain in the North Sea in large numbers except in the spawning season, and it is most likely that they retire into the deeper and more northern waters of the Norwegian sea. The migration, therefore, seems to be towards and away from our coasts. How far away from our shores these migrations extend, and whether the fish remain permanently in shoals, are questions left for future generations to answer. We can only be extremely grateful to the herring for developing races which breed respectively at all seasons of the year, and for so conveniently choosing our coasts as suitable grounds for depositing her millions of eggs.

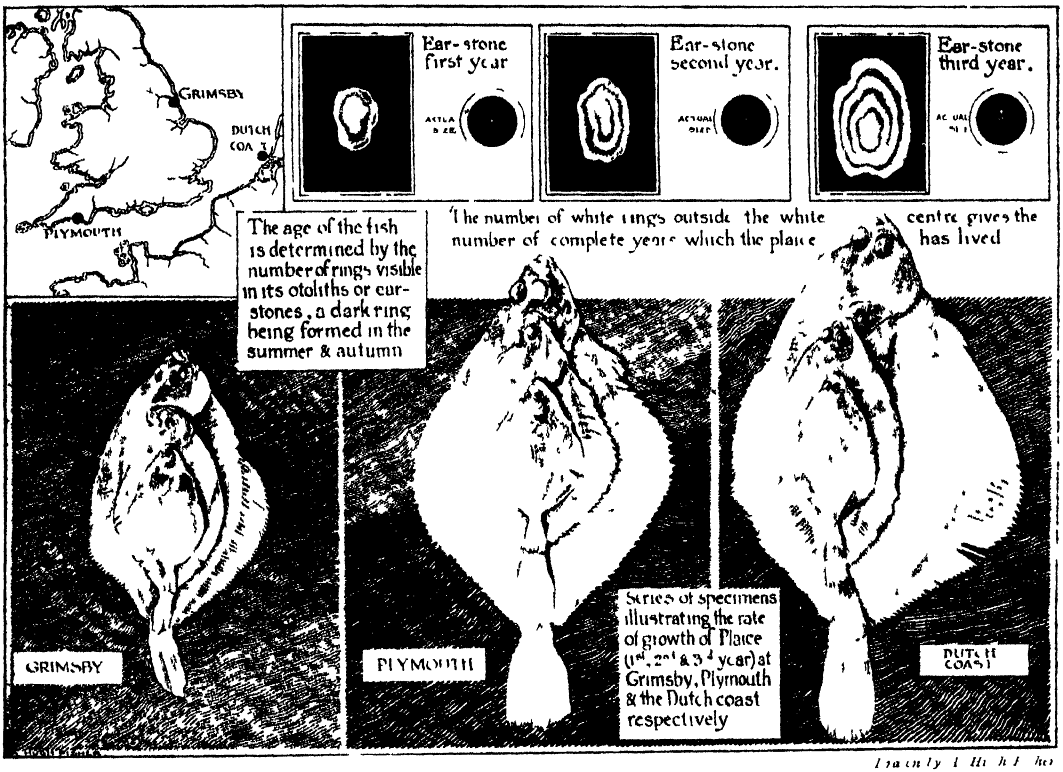
Rival Theories

Another interesting fish of this family is the sardine, or pilchard, as it is called when adult. The young fish or sardines afford a valuable fishery on the west coast of France, and then apparently move off from the coasts to spawn, fifty miles or so, out to sea, returning when mature as pilchards, to spend the winter round our coasts. The movements of the sardine are not well understood, for in some seasons it is totally absent from localities where in previous years it has been extremely numerous. The anchovy is very abundant in the Mediterranean and in the Zuyder Zee, where it is regularly caught. This little fish seems to breed in the Dutch estuaries in summer and then to make its way southward by way of the English Channel and along the Continental coast.

The mackerel family are active predaceous fish, which live in shoals and hunt their prey by sight. The mackerel himself is one of the swiftest inhabitants of the sea, and he is remarkable for his extensive migrations. He is essentially a lover of coasts, but is very widely distributed, extending from the south of Norway to the Canary Islands and throughout the Mediterranean. In the spring these fish approach the coasts to spawn, and as soon as this duty is over they retire to the deeper waters away from the land. Later in the year they reappear near the coasts, but this return is due to their following up the inshore migration of larval fishes of different species. Their own young, however, remain in the open sea during their first six months. When winter approaches and the temperature of the water near the coasts drops to less than 45° F., the mackerel departs for the warmer waters of the Atlantic, there to remain till the advance of spring calls her back to repeat the great business of producing 450,000 eggs apiece! By May huge shoals have come right inshore; during June and July they are numerous; by August they are gone, to return again later for a month in pursuit of the small fry. Thus it is clear that the spawning instinct, the food supply, and the temperature of the water all influence

The Mackerel Family

the movements of this species. The tunny is another near relative of the mackerel with very wandering habits; they arrive off the coast of Portugal in May, enormous numbers proceed through the Straits of Gibraltar and supply a large fishing industry in the Mediterranean. During the month of August a return migration takes place, and they reappear on the coast. The tunny is the only warm-blooded fish known, and can attain an enormous size.



The age of the fish is determined by the number of rings visible in its otoliths or ear-stones, a dark ring being formed in the summer & autumn

The number of white rings outside the white centre gives the number of complete years which the plaice has lived

Series of specimens illustrating the rate of growth of Plaice (1st, 2nd & 3rd year) at Grimsby, Plymouth & the Dutch coast respectively

[illegible]

How to Tell the Age of Plaice by Scales and Ear-stones

Turning now to fish which are both marine and fresh-water living, we find two totally opposite habits. In some forms the sea is the usual habitat, and the fish ascend rivers to spawn; in others the reverse is the case, the fish living for the most part in rivers and seeking the sea when the breeding impulse is felt.

A very interesting example of the latter is found in the common eel which inhabits the greater part of Europe, North Africa, temperate Asia, and the Atlantic side of North America, Mexico, and the West Indies. For many years the breeding habits of this fish remained a complete mystery; the fact that eels taken in fresh water never showed a ripe spawning condition could in no way be accounted for. Not till 1874 was it discovered that they require salt water in which to become sexually mature. Now it is known that the very deepest and most central parts of the Atlantic Ocean, over a thousand miles from land, form their spawning ground.

On dark, wet, and windy nights in September the mature eels, four or five years of age, make their way down our rivers in large numbers to the sea. They then retire into the abysses of the ocean, where they acquire larger eyes to enable them to penetrate the gloom which prevails at these great depths, and deposit their numerous floating eggs. The eggs develop into a strange creature, which for a long while was thought to be a distinct species. It was called *Leptocephalus brevirostris,* and is a flattened, transparent fish, totally unlike the elver into which it turns by a gradual transformation. During this metamorphosis the larva does not feed, and so becomes smaller and reduced in depth until it is finally transformed into the elver.

Metamorphosis of the Eel

These young larvæ are probably carried by the Atlantic drift towards the shores of Europe, and complete their metamorphosis on the Continental shelf. Countless thousands of these eel fry ascend the rivers from April onwards, when they are about six months old, and no doubt they are the offspring of eels which descended to the sea the autumn before. A big migration continues for about a fortnight, during which no barrier seems impassable to these gallant little travellers; and even if the current is too strong for them they ascend by means of the grass and weeds of the river's bank. On a calm day their upward movement makes a ripple on the quiet waters like that caused by a gentle breeze playing on the surface. The parents, however, never return again to their old home, but perish miserably, after doing their utmost for the maintenance of the race. The instinct to go to the death which awaits them in the abysses of the Atlantic is exceedingly strong, and when eels are confined in ponds without outlet and are unable to find water leading to the sea, they have frequently been known to travel considerable distances overland in their endeavours to find running water. What great impulse causes the elvers so persistently to struggle on up every river and stream is a mystery; it is not their old home they are seeking, but the old home of their heroic parents who have died to give them life!

Perhaps the group of fishes whose migrations and habits have been most studied of late years is the salmon family, and no doubt they fully deserve it on account of their beauty and great gameness. This genus is divided into three sections, the Quinnat salmon of the North Pacific, the salmon and trout, and the charr of the lakes of Europe, Asia and North America.

The King or Quinnat salmon inhabits the North Pacific, where it reaches the age of four years and attains the average weight of 22 lb. before it proceeds to ascend rivers. This occupies it the whole summer, and by November it reaches the spawning beds at a distance of from one to two thousand miles from the sea. It is by this time in very poor condition, and after spawning operations are over, the unfortunate fish are completely exhausted and drift helplessly down stream, tail foremost, in an almost lifeless condition; none are said ever to regain the sea alive. Such is the reward for their efforts to propagate the species!

The Common Salmon

The common salmon inhabits the seas and fresh waters of Europe, Asia, and North America, and varieties are also found in Australia. The fact that salmon ascended the rivers periodically has been known since the earliest times, and is known, too, by such uncivilised peoples as the Australian aborigines. These blacks are in the habit of making dams and pools by driving branches and stakes into the river bed; and while the rivers are in flood, and the fish are travelling down stream, they are driven into these pools and caught. North American Indians make barriers of logs across the rivers to stop the ascent of the salmon; in Britain fishing weirs were made in England and cruive dykes in Scotland, these structures corresponding with the native barriers found now in Australia and North America. It may be interesting to trace the life-history of this fish as far as it is at present known. To begin at the beginning: the eggs are deposited in the gravelly beds of rivers and streams in the months of November and December. Between 70 and 120 days elapse, according to temperature, before the eggs hatch

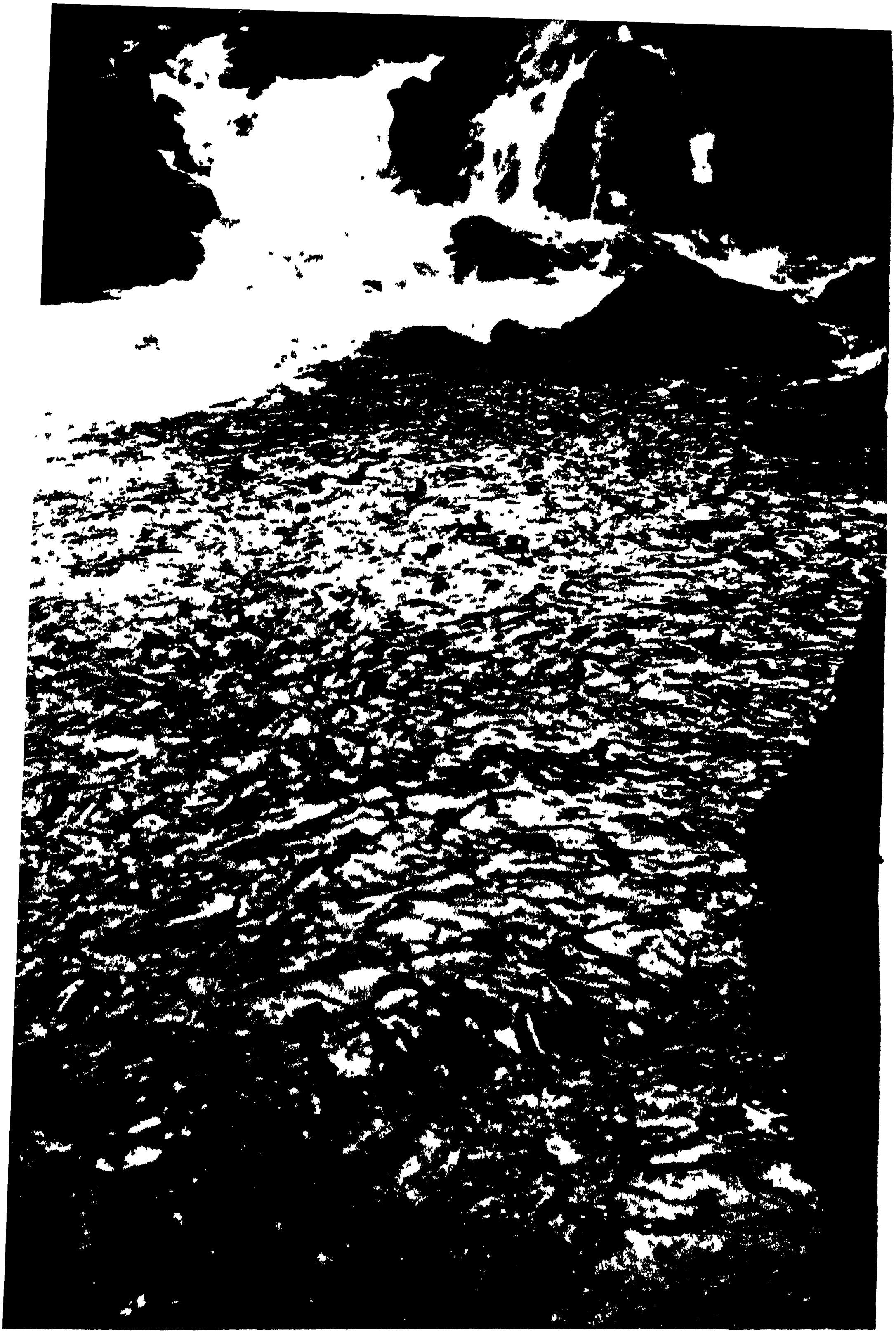


Photo C A Fuhle

The Migration of Salmon from Salt Water to Fresh

This photograph shows a run of salmon making their way up stream from the sea in Alaska, packed so tightly that one might almost cross the river on their backs into grotesque little creatures known as alevins; these carry a large yolk sac, which provides them with sufficient nourishment to last them several weeks. Towards the end of this time they commence to search for food on their own, meanwhile travelling energetically up-stream. Very soon they lose their odd appearance and become transformed into small fishes commonly called fry, which collect into shoals. By the autumn following their birth they are from two to three inches in length, and are now known as parr.

After the end of September these little people hide themselves under stones where they remain, almost without feeding, till the following spring. During this time they lose their good condition and become black and considerably smaller. As the season advances they again make their way up stream as far as the water will take them. A rapid increase in dimensions takes place, and by the autumn, when they are two years old, they have attained twice the size they were at the fall of the previous year. During the coldest months they retire once more to their old haunts, leaving them again in March, to feed.

Departure of the Smolts

In the month of April a great change takes place in their appearance, the beautiful silvery smolt dress being assumed and a more graceful shape acquired. This is their migratory dress, and the interesting part of their lives now begins. An old rhyme has it that "the first floods of May take all the smolts away," and this is probably, to a great extent, correct. The smolts make the descent of the rivers in large shoals, and from observations carried out in an estuary they apparently congregate in great numbers at the extreme upper limit of brackish water, and from thence make steady and comparatively rapid progress to the open sea. This departure of the smolts to the salt water finishes the first stage of the salmon's life. After this point observation is difficult, as we have no means of ascertaining where the small fish go to or what kind of lives they lead. Herring and sand eels seem to be their chief food, and they appear to frequent the same habitat as mackerel and herring.

Return of the Grilse

Our next acquaintance with them is when they return to the rivers as grilse—and this is usually about fourteen months after they left the rivers as smolts. It is during this period that the fish makes the best of the abundant food furnished it by the salt water and grows very rapidly. Grilse enter our rivers in what one might almost call an overfed condition, and are consequently able to fast for long periods, living entirely on the food stored up in their tissues. It has been said that after overeating itself in the sea, it is necessary for the salmon to come into fresh water in order to rest. This implies that salmon are fresh-water fish which go to the sea to feed, but of late it has been found that salmon really spend the greater part of their lives in the sea; this, I think, points to the probability of the salt water being their original habitat, as it is with most other members of the family.

The run of grilse continues from May to December. Spawning commences in the first week of November. A great many fish return at once to the sea after spawning, but some remain till the spring and are consequently very poor in condition and much reduced in weight by the time they regain the sea. This second sojourn in the sea varies from four to eighteen months. During this time they sometimes travel considerable distances from the coasts—marked salmon having been caught at a distance of fifty miles from the estuary where they came from. A great increase in size takes place while they are in the sea, and in the following summer, about June, many return as salmon twice their former size. These fish which have only been a short time in the sea—namely, about six months—are the best-conditioned, especially those which did not spawn the previous year. Those which have spawned once are termed kelts, and are distinguishable by their coarser, whiter flesh, and by the fact that the edges of the scales on the under surface are worn and ragged. Before the plan of marking salmon was started, these fish were called bull trout, but from the results of marking fish their change in appearance is now known to be due to their having spawned. Another interesting feature brought out by salmon marking is that the fish tend to return to the same stream where they were born, though in many cases they have been caught in the sea at a great distance from their native river. It is, however, quite probable that some fish in the search for food and in the pursuit of herring shoals may occasionally lose their bearings and be unable to retrace the way to their old home. It has now been fairly well established that salmon only spawn once or at most twice in their lifetime, though they do return more than once to fresh water. This looks as though the theory of salmon entering fresh water to rest from an over-nourished condition was the most probable explanation of their migrations. Dr. Noel Paton says, "When the salmon has accumulated the necessary supply of material, it tends to return to its original habitat," namely, the river. However, this is a question which still remains to be answered, and much is being done in this direction by the study of the scales.

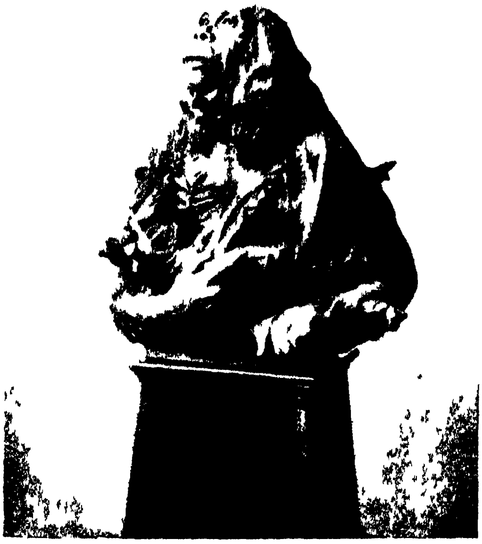
The most remarkable feature of salmon migration is the demonstration of what has been called the "divided migration," that is, the habit of the fish to remain for long and short periods in the sea. Fresh water is essential to the salmon for breeding purposes, but often it leaves the sea long before the time for spawning; the fish which come up the rivers in spring are those that have spent the "long period" in the sea and have in consequence missed a spawning season, having descended the river the spring before. It may be that those fish in the habit of spending the long period in the sea are of a different race to those which only remain for a short period.

The problems of salmon migration are many and difficult, but whether they will ever be solved or not, the pleasure of catching a clean fish will always remain a keen one to the British sportsman.

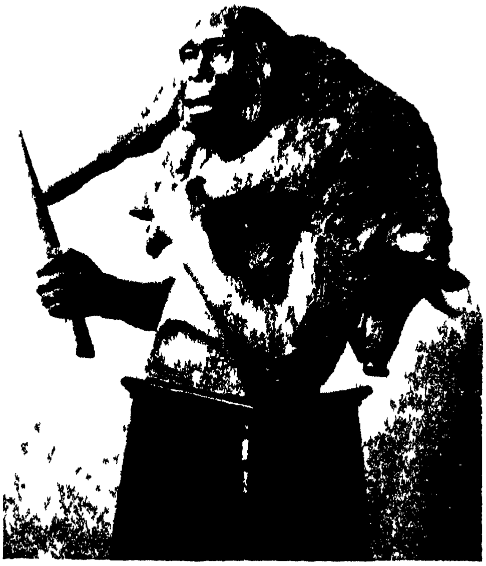
Photo C R Fickle

How Salmon Leap Apparently Insurmountable Obstacles

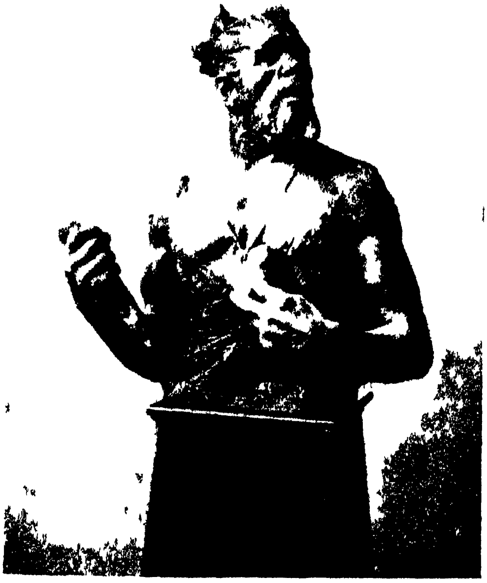
The photo shows six salmon jumping together up and over a cascade at the Ketchikan Falls, Alaska



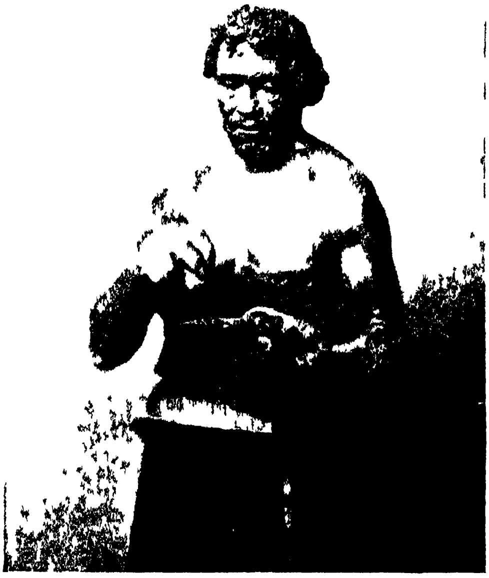
Pithecanthropus erectus



The Heidelberg Man



The Galley Hill Man



The Grenelle Man

The Rise and Progress of Man

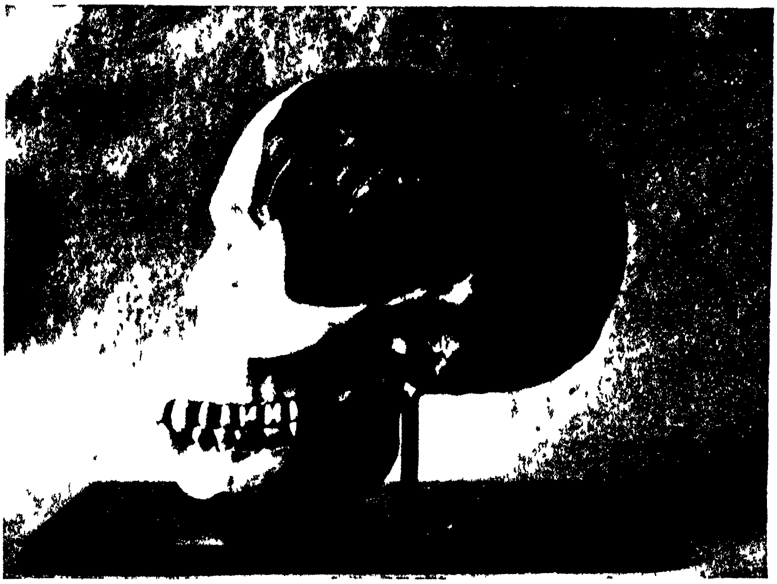
This interesting series of busts (continued on pp 854-856) has been modelled by Louis Mascré, under the supervision of the Belgian Professor Rutot, whose conclusions they represent

Wonders of Life in the Ancient World—III

The Rise and Progress of the Human Species

By SIR H. H. JOHNSTON, G.C.M.G., K.C.B.

CURIOUSLY enough it is in the matter of Man's ancestry, of the links between Man and the Ape, that Nature has been most coy and reluctant in yielding up her secrets of fascinating interest. During the course of the nineteenth century we have had revealed to us many of the missing links in the genealogy of other orders and families of mammalia, but at the time when Darwin, Huxley and Haeckel were attempting by the evidences of fœtal development and of analogy in the shaping of other forms, to set forth an acceptable theory as to the origin of Man, they derived very little encouragement from the records of the rocks. The only indication before them of the existence in former times of a type of man scarcely to be classed as *Homo sapiens*, was the description given in 1856 of the famous Neanderthal cranium, and the equally remarkable and more complete remains in skulls and limb-bones found at Spy in southern Belgium during the sixties.



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The Face of the Piltdown Skull in Profile

Restored by Dr. Smith Woodward for the Natural History Museum, London

It is true that in the same period a very remarkable skull was found in a cave at Gibraltar and sent to England, but the affinities and characteristics of this now celebrated cranium were not made clearly known to us until about four years ago by Professor A. Keith, of the Royal College of Surgeons. The most startling advance in the discovery of the "missing link" was that made by a Dutch scientist, Dr. Eugene Dubois, who, in 1892, whilst investigating the fossil remains of mammals in a bed of volcanic ash in Central Java, picked out of these remains of long since extinct elephants, tapirs and buffalo, the imperfect roof of a skull, two molar teeth, and a femur or thigh-bone. He at once realised he had found evidence of a creature which, though nearly related to humanity, was still outside the genus Homo, and almost midway

Ancient British Lake Village near Glastonbury, 2,000 Years Ago

(Drawn by A Forestier)

This village was situated about a mile north of Glastonbury It was surrounded by a palisading of piles (held together by hurdle work) sloping outwards like a *chevaux de frise* The hut walls were about 6 feet in height. The landing stage and drawbridge are seen on the left in affinities between the Ape and Man. He gave it the name of *Pithecanthropus erectus,* for he realised that this thigh-bone declared it to be a creature that walked erect like Man, though its brain-case was only two-thirds of the capacity of the normal human cranium. During the twelve years that followed, other discoveries of extinct members of the human genus were found in France and Germany. These all belong to the Neanderthal type, but the most remarkable amongst them, that represented by a lower jaw discovered at Mauer, near Heidelberg, in 1904, was apparently the oldest in point of age of any purely human remains yet discovered, dating back to the commencement of the Pleistocene or Glacial period. It was probably pre-Glacial, and the man to whom it belonged must have been almost a giant in size, or, at any rate, had a very large head and trunk. Yet, though he was of the Neanderthal species, quite distinct from *Homo sapiens*, he was probably able to talk after a fashion in articulate language.

The nearest addition to the "missing link" series after *Pithecanthropus*, was actually discovered at the bottom of a gravel-pit at Piltdown, near Buxted, in south-central Sussex, in the year 1912. These remains consisted of the greater portion of a skull and of a lower jaw, and (later on) a canine tooth. The discovery of these remains being due to the perspicacity of Mr. Dawson, a Sussex archæologist, the name *Eoanthropos dawsoni* was given to this early type of Sussex hominid by Dr. Smith Woodward, who promoted and assisted in the discovery, and who attempted the first reconstruction of the fragments. Dr. Smith

Photo [illegible]

A Real Savage of the Present Day

A wild Ona Indian of Tierra del Fuego, leading the life our ancestors led in the Early Stone Age

AT THE LANDING STAGE OF THE PREH

(Reconstructe

On the extreme left are seen men digging out a boat, one of those comparatively well-formed craft which were sc
their nets Then there is a slave putting clay in baskets preparatory to conveying it into the village. In the centr
the form of swans, the men on the right with meat. It will be noted that the hunters are armed with iron-hea
though this is not certain. Undoubtedly, they knew the value of the sling, for thousands of sl

TORIC LAKE VILLAGE NEAR GLASTONBURY

A Forestier)

ighteen feet long, and obviously sturdy Next to these, and on the right looking at the picture, are fishermen hauling in
a chief, accompanied by two attendants, welcoming the return of a hunting expedition, the men on the left with fowl in
and stone-headed spears. It is probable also that they used bronze for their weapons and had bows and arrows,
pellets of baked and unbaked clay, shaped by rolling between the hands, have been unearthed

According to Prof Rutot

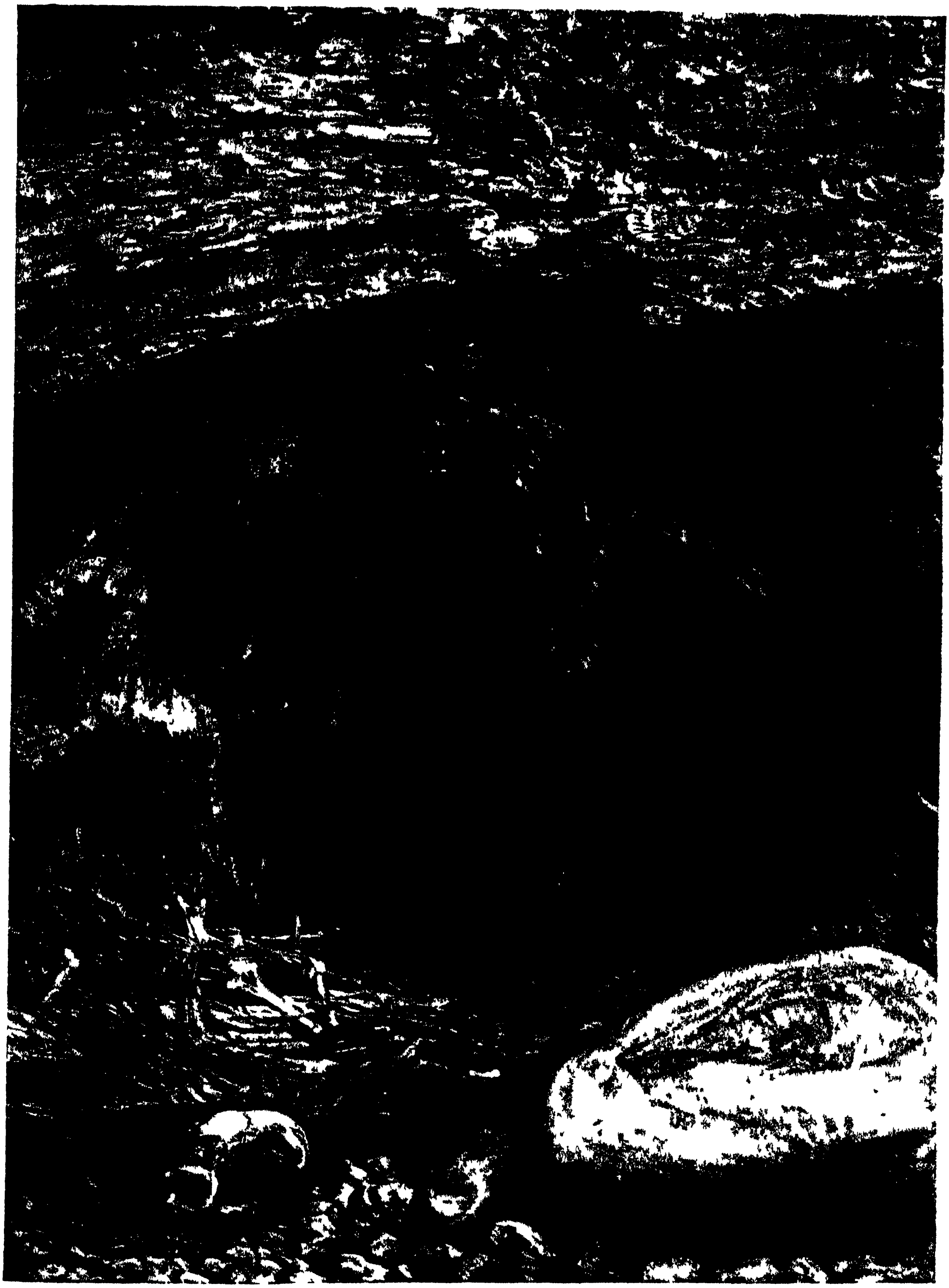
The Neanderthal Man

Woodward deduced from these remains (apparently of a woman) the existence, at a period which may have been the close of the Pliocene, perhaps 700,000 to 1,000,000 years ago, of a creature nearly, but not quite, human; almost, if not actually, an ancestor of modern Man. The skull lacked the prominent brow-ridges of the adult male Gorilla and Chimpanzi, of Neanderthal man, and the living black Australian or Melanesian races; though as the skull was probably that of a woman, the male of the same species may have had more prominent brow ridges. The brain capacity was quite human and equal to that of the most backward types of humanity known at the present day: say, between 1,000 and 1,100 cubic centimetres. But the lower jaw and chin were shaped like those of a chimpanzi, and lacked the genial tubercle which is associated with the modern development of human tongue muscles and the possession of articulate speech. Unlike, therefore, the man of Heidelberg, who came into existence 100,000 years or so later, the woman of Piltdown was unable to speak in the articulate human fashion, and probably only uttered uncoordinated cries, lip-sounds and tongue-clicks, like those of the apes and baboons. Moreover, there were indications, since confirmed by the actual discovery of a canine tooth, that the teeth in the upper and lower jaw were not closely consecutive one to another as in true humanity, but had slight spaces between the canines and incisors, and the canines were larger, more prominent, and more pointed than those of True Man. In short, *Eoanthropos* is one of the hitherto missing links between humanity and the beast world.

Down to a few thousand years ago, it was thought that the Man of Neanderthal (whose remains have been found over Central and Western Europe from Austria to Jersey and Gibraltar) was an earlier stage in the evolution of *Homo sapiens*, the modern Man; but we know now (chiefly owing to the investigations of Professor A. Keith) that *Homo primigenius* as the Neanderthal species is sometimes styled

According to Prof Rutot

The Combe-Capelle Man



By W H [illegible]

The Last of the Ogres

Such types as these were the origin of those legends of ogres that haunted the imagination of our ancestors in the historical period long after the last of the ogres had been slain by some Neolithic civiliser. He is here shown emerging from his cave to face the attack of some superior type of humanity

was an early offshoot of the true human stock, which was decidedly not in the direct line of ancestry of *Homo sapiens.* The species of which we are—all living men on the planet—divergent examples, originated probably coevally with or anterior to the Neanderthal type, which last in its latest developments became so specialised that in the opinion of Professor Keith it could not even have mingled with *Homo sapiens* and produced fertile hybrids. (The chief differences between *Homo primigenius* and *Homo sapiens* are in the structure of the roots of the molar teeth and the shape of the palate, in both of which points the Neanderthal Man is *less* primitive or ape-like, and more specialised, than most examples of *Homo sapiens.* Nevertheless, Neanderthal Man had preserved the great simian brow-ridges, the shorter hind-limbs, the bowed shin, and other ape-like characteristics, usually lost by our immediate ancestors, though to some extent retained in the Black Australian and Tasmanian).

The Black Australian and the extinct Tasmanian, together with the Veddahs of Ceylon, and some of the Melanesian types of the New Hebrides and New Guinea, represent on the whole, in spite of their own specialisation, the type of primitive man of the Sapiens species which inhabited Europe from 500,000 to 100,000 years ago; but no doubt to an even later period there lingered in Europe specimens of earlier ancestral types, showing, like the Piltdown man, a greater size and separateness in the canine teeth, more divergent and flexible big toes, and a considerable hairiness of body. At the present day the hairiest of human races is the Black Australian, and next to that many races of Europeans, including their far-distant allies the Ainu of Japan. From indications that we get in the rock drawings of Palæolithic Man in the French caverns, it would seem that a hairy condition of body in cold climates continued down to a period not very remote from the development of Neolithic Man—say 20,000

The Cro-Magnon Man

The Neolithic (Later Stone Age) Man

(Photos from busts modelled by Louis Mascré under the supervision of Prof. Rutot)

to 30,000 years ago. There are also indications that Palæolithic Man, besides being mainly carnivorous in his food and a great hunter, could also become a cannibal, like so many of the savage human races at the present day in Africa, South America, and Oceania. Such types as these, no doubt most ferocious in aspect, with great bodily strength developed in the male, and a gruesome hairiness of body, were the origin of those legends of ogres that haunted the imagination of our ancestors in the historical period, long after the last of the ogres had been slain by some Neolithic civiliser. We are accustomed in thinking of early Man to picture him as black-haired; but, in all probability, amongst the earliest developments of the genus and species of *Homo* there were races of red-haired people; or in some tribes the men may have been black-haired and the women red-haired. This red hair, with a somewhat savage type of facial feature, persists to the present day in the peoples of Northern Europe, from Russia to Caledonia and Ireland. I have, therefore, without undue licence of imagination, preferred to picture "the last of the ogres" - emerging from his cave to face the attack of some superior type of humanity —as not only red-haired and dark-skinned, but with his body covered in parts by fleecy hair.

The "Negroid" Grimaldi Man and "Negroid" Laussee Woman

(Photos from busts modelled by Louis Mascré under the supervision of Prof Rutot)

The Wonderland of Bird Song

Soloists and Choristers of the Feathered World

By W. PERCIVAL WESTELL, F.L.S., M.B.O.U.

THE average individual, if asked to mention the names of a few British song birds, would probably stop short when he had reached some half a dozen species. The reason is not far to seek, for several of our finest song birds are of shy disposition, a number of them are only summer visitors (mostly from Africa), and unless their songs are carefully studied by the field ornithologist, they can easily be overlooked.

The [illegible] Chatham

Hen Wheatear Feeding Young

Then, again, to those who have an untrained ear, the chorus of birds during spring and the early days of summer is merely a babel of voices, a pandemonium of song. It is, in reality, a difficult matter to pick out the solos of individual performers, particularly when the avine orchestra has reached its height.

Differentiation in the matter of bird song is, as a rule, somewhat disappointing. Field ornithologists are among the first to recognise that very often a bird is seen or heard under very favourable circumstances. Even though one has listened times out of number to the soul-inspiring lyrics of the song-thrush, as it perches on a naked bough in early spring, or to the mellifluous blackbird, which contrives to hide its sooty body in the thick retreat of a leafless thorn bush, a certain individual performer among the throng will stand out from the rest.

So, too, one *sees* birds sometimes under very favourable conditions. I must have watched and listened to thousands of linnets during my thirty odd years of bird work in the field, but one particular bird will not readily be effaced from my memory. It must be, at least, ten years ago, but, as I write, that individual songster is still before me, though my country study is surrounded with linnets the livelong day,

The Tree Warbler discovered by Lieut. Boyd Alexander

(Drawn by H. Grönvold)

This beautiful little bird was discovered by Mr. Boyd Alexander during his ornithological survey of the island of Fernando Po in the Bight of Biafra. It is found only in the misty surroundings of the mountain heights and hundreds roost within hail of me every afternoon during autumn and winter.

The garden warbler, a species which, in my opinion, is to be reckoned among the most beautiful British song birds, is very little known to the man in the street. Indeed, I have met practised ornithologists who were unacquainted with its minstrelry. It is a shy, recluse bird; it hates being watched. It sings and hunts for food at the same time. It dearly loves to take cover among oak leaves, or in a sycamore, and though its sweet liquid song may, on occasion, be mistaken for that of its more renowned cousin, the blackcap, patient listening will eventually result in the observer being able to distinguish one bird's song from the other.

Birds, like their human prototypes, differ in a very marked way. Last spring, two male blackcaps sang day after day within earshot of my study. One of them was what may be termed an ordinary performer. Its song, whilst sweet and inspiring, could not be compared with that of its rival in a neighbouring bush. This latter bird was, as a matter of fact, the most marvellous mimic I have ever heard. I could easily detect in its song the notes of the thrush, blackbird, wren, whitethroat, robin, goldcrest, nuthatch, linnet, nightingale, garden warbler, and greenfinch. I listened intently to this bird for days at a stretch, for its repertoire was amazing both in quantity and quality. Thus, until a successful rival appears, I shall always regard that individual songster as the most wonderful I have ever heard.

Some birds are solitary singers, others prefer to sing in chorus. The dipper, which haunts our northern streams, belongs to the former category, and sings equally well on a cold winter day. The linnet is a chorus singer *par excellence;* indeed, as an individual soloist, this favourite finch does not accomplish anything great.

As a rule, the garden warbler is a solitary performer, but I once heard a company of

Photo T A Metcalfe

Goldfinch

Photo T A Metcalfe

Garden Warbler

these birds singing in chorus. They had only recently arrived upon our shores, and their songs, as listened to upon a bright spring morning towards the end of April, were very beautiful indeed.

Some birds have a restricted song period. The nightingale is one of these. It arrives on our shores about mid-April, and at once executes its vocal powers. By the end of May, however, its voice shows signs of failing, the rich liquid notes giving place to a series of hoarse croaks, which it is difficult to associate with a song-bird possessing such a renowned pedigree.

Photo J. A. Metcalfe

Grasshopper Warbler on Nest

On the other hand, the skylark, robin, hedge accentor, and wren have a lengthened song-period, singing for many months out of the twelve. The skylark is undoubtedly the most continuous song-bird which we have in Britain, for it sings at least ten months out of the twelve, and in all weathers. As is well known, it sings and soars at the same time, though not invariably, as, like a near relative, the tree pipit, it will, on occasion, give voice when perched on a post, fence, low bush, or the ground.

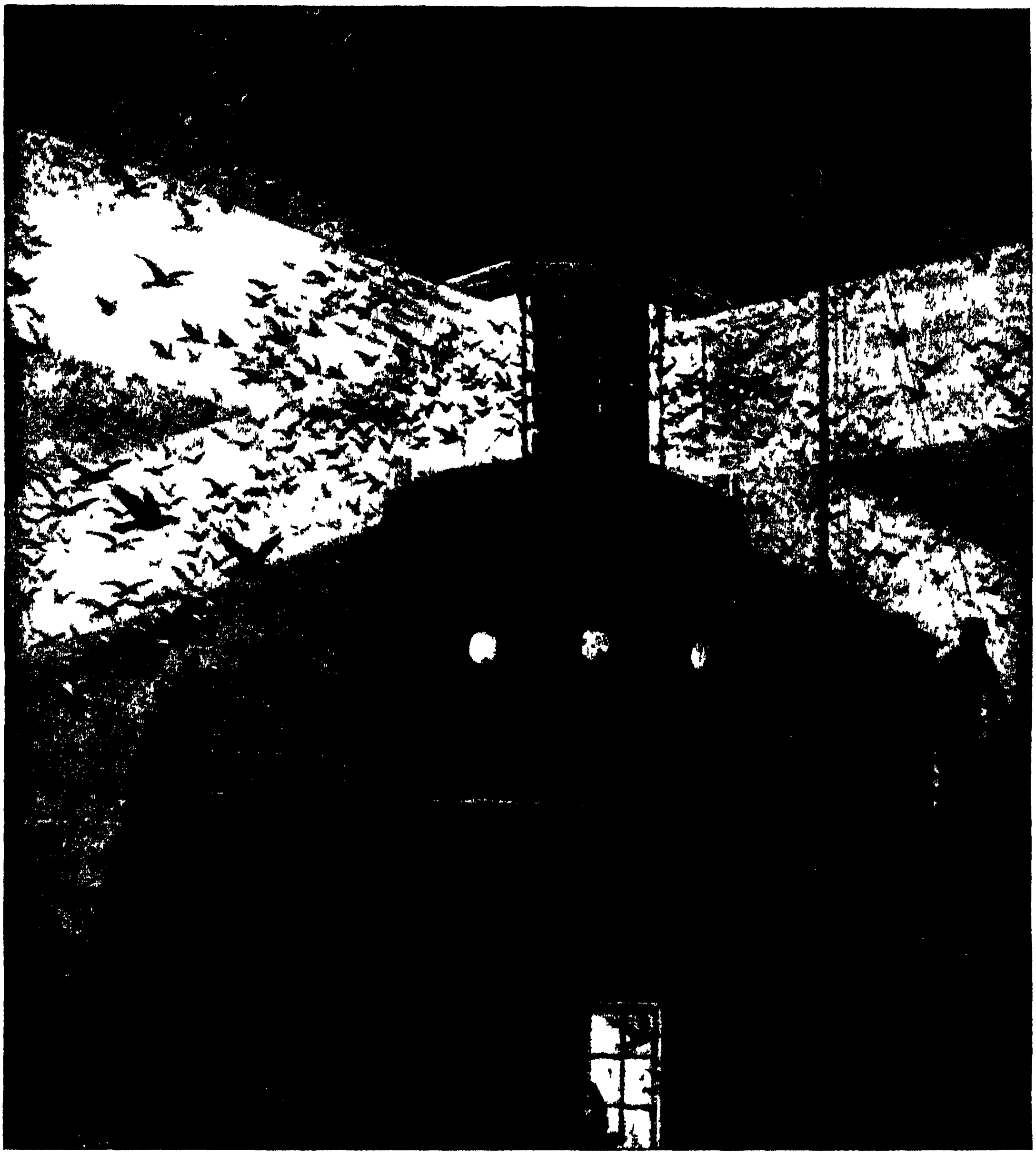
Birds which sing upon the wing are very few. Two have just been mentioned, the skylark and tree pipit, to which may be added the meadow pipit, greenfinch, linnet, greater whitethroat, goldfinch, lesser redpoll, and wheatear. When the latter goes a-courting, he is well worth watching. He is a handsome bird when he arrives among us from his Southern home, and approaches his would-be consort by means of vocal blandishments as he hovers in the air.

The hedge accentor has of recent years taken to keeping very late hours, and may often be heard singing far into the summer night. So also do the skylark and the sedge warbler. To hear birds at their best, one should be out as soon as it is light during March, April, and May. Then their songs seem fresher, clearer, and more captivating. The blackbird's early morning song is, for example, in the nature of a matin, but towards evening its notes strike one as more vesper-like and sad.

The robin's autumn dirge falls upon the ear differently from the sprightly notes of spring, and there is a touch of melancholy in the simple strain of the hedge accentor when the land is in the grip of winter.

Upon the moors, where song-birds are scarce, the few clear notes of the ring ouzel, or moor blackbird, as it is also called, are particularly refreshing, whilst where furze bushes flourish upon a broad, breezy common, the chatter of the stonechat, flitting from bush to bush, contrasts pleasantly with the sweet little song it also utters, if we except the shrill cry of the jackdaw and the gruff salute of the sable rook.

The chaffinch varies a good deal as a song-bird, and it is amusing to hear them practising in early spring. If the notes were not so high-pitched, less shrill, and



Drawn by Frank Pitt [illegible] Thijsse

A Night Scene at Terschelling Light during the Migration of Birds

Owing to thousands of migrants dashing themselves to death against the lighthouse glass, or flying around the fascinating light until they drop from exhaustion, Professor Thijsse has arranged perching rods on the lighthouses on Terschelling Island, affording resting-place for thousands of birds

Of all familiar bird sounds, the rustic note of the greenfinch, and the plaintive ditty of the yellow bunting, are most rural.

Photo: T. A. Metcalfe

Tree Pipit Going on Nest

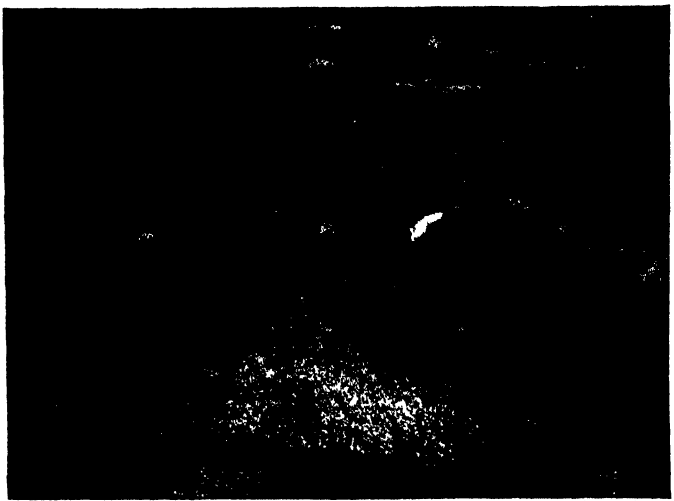


Photo: Oxley Grabham

Female Dipper Feeding Young

Photo: T. A. Metcalfe

Bullfinch on Nest

more melodious, they might pass muster for those of a summer visitor, the willow warbler; and, later in the year, the remarkable stridulating song of the grasshopper warbler may be heard in those districts favoured by this somewhat rare species. The song is little varied, only the rising and falling, due to the male bird's habit of turning its head rapidly from side to side, giving any variation to one of the most electric sounds in the whole arena of Nature.

The blackcap is a very wonderful songster, though, truth to tell, some individual performers are not calculated to send the listener into a frenzy of delight.

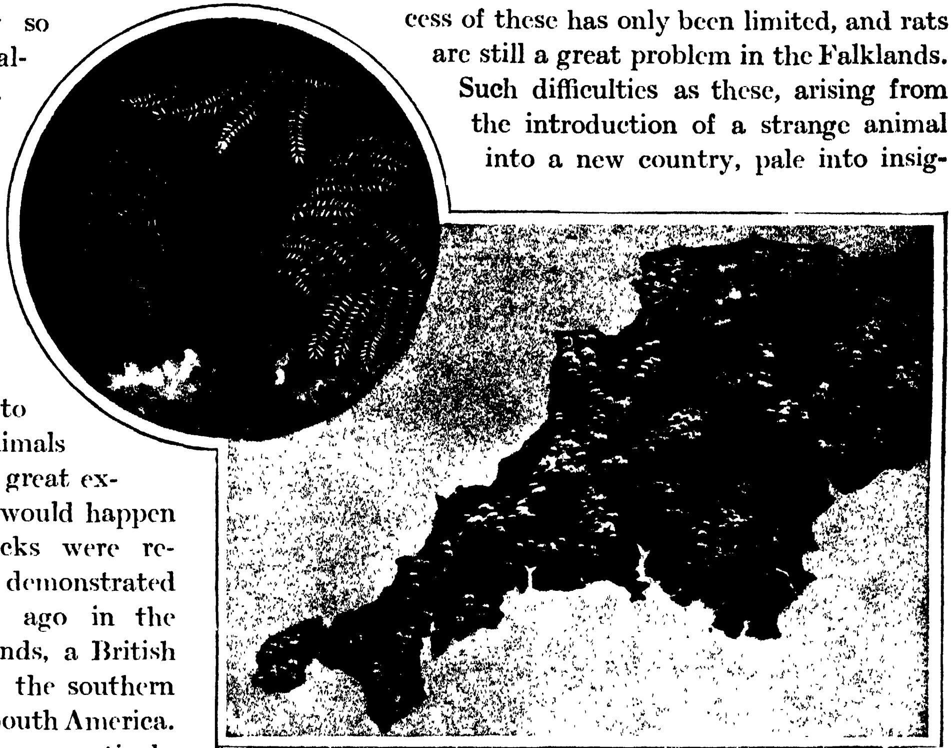
The goldfinch is really a cheery songster, and never seems happier than when extracting seeds from thistle-heads in autumn. When thus engaged, numbers may be heard singing together. Its cousin, the bullfinch, is, curiously enough, by no means a brilliant songster in a wild state, yet young bullfinches can be taught to pipe most beautifully, and fetch a high price as cage-birds.

Few people appear to know that the swallow is quite a good song-bird, twittering in a most pleasant manner, both when flying and at rest; and, though the pied wagtail more usually gives vent to its feelings by exclaiming in a shrill voice, "Tizit, tizit, tizit," it can, if it is so minded, sing really well. Truth to tell, I have only heard it thus engaged on very few occasions, and, such being the case, it is worthy of record in these notes concerning the wonderland of bird song.

Upsetting the Balance

By S. LEONARD BASTIN

IT is always a risky thing to interfere with Nature's arrangements for the distribution of animals or plants. As we have already noted (p. 146) the transportation of something so harmless as a sparrow to a new locality may so "upset the balance" that it becomes a veritable plague in that district.



A Prolific Fern

If the conditions were such that all the 4,000 million spores of a single *Angiopteris* fern came to maturity, enough plants would be produced to cover Devon and Cornwall

Rats have many enemies, and these serve to keep the animals in check to a great extent. What would happen if these checks were removed was demonstrated a few years ago in the Falkland Islands, a British possession off the southern extremity of South America. Up to within comparatively recent times rats seem to have been unknown in this out-of-the-way corner of the world. However, one day a large barque drove ashore in a South Atlantic gale and, as the ship broke up, the rats deserted her and scrambled on shore. Nothing much happened for some months, and then it began to dawn upon the islanders that their supplies of food were being attacked in a most voracious manner. The comparatively few rats which landed from the ship increased simply because there was nothing to check them. At one time it seemed as if the unfortunate inhabitants of the Falkland Islands would have to flee before the threatening army of rodents. Various means of coping with the plague have been devised, but the success of these has only been limited, and rats are still a great problem in the Falklands.

Such difficulties as these, arising from the introduction of a strange animal into a new country, pale into insignificance, however, when compared with those which have followed when the newcomer has been a plant. Many people know the story that it was a loyal Scot who, when emigrating to Australia, took some roots of the national emblem with him. Whatever the truth of this tale may be, there is no doubt that the thistle was somehow introduced into this continent.

The results have been simply appalling, for the rank weed has prospered to such an extent that farm crops of all kinds have been crowded out. Laws have been passed making it illegal for the farmer to allow the plant to set seed, but there seems to be little hope of eradicating the pest. Just what it is which keeps thistles in check in Britain no one seems to know, but it is quite evident that this restraining influence is lacking in Australia.

The Burweed

An even more amazing instance of an introduced plant becoming an intolerable nuisance is that of the burweed. This plant, which is of European origin, bears seed vessels which are covered with hooks. These attach themselves to the coats of passing animals, and thus get distributed. Fifty years ago the plant was quite unknown in Australia, but somehow it was introduced, though in what way has never been discovered. In its new country the burweed prospered greatly and spread in all directions. It was not long before the sheep farmers realised that the coming of burweed threatened to kill the most profitable part of their industry altogether. The hooked seed vessels of the burweed get entangled in the wool of the sheep, and, as it is almost impossible to get them out, the material is rendered quite useless. All kinds of steps have been taken to exterminate this pest, but the plant is still an intolerable nuisance. In some districts it is estimated that half the wool which is produced is spoilt by the seed vessels of the burweed.

The burweed was introduced into South Africa in a singular manner. A ship laden with a cargo of wool from Australia was wrecked on the coast of Cape Colony. Some of the wool contained the seed vessels of the weed, and these were carried on shore by the violence of the gale. Quickly the seeds grew into plants, and these in turn produced seeds which were scattered all over the Colony. As one would expect, the plant has become a real nuisance in its new home, and is causing great trouble to sheep farmers.

Many kinds of water plants have spread to distant countries, and have proved a great nuisance. One would think offhand that there was not a more harmless plant than the water-cress. It seems to have been a very natural step to introduce this agreeable salad into New Zealand, yet in its new surroundings the plant has proved to be a dreadful curse. It grows with such vigour that special legislation has been introduced to deal with the pest. All over the country important waterways are wellnigh blocked by water-cress.

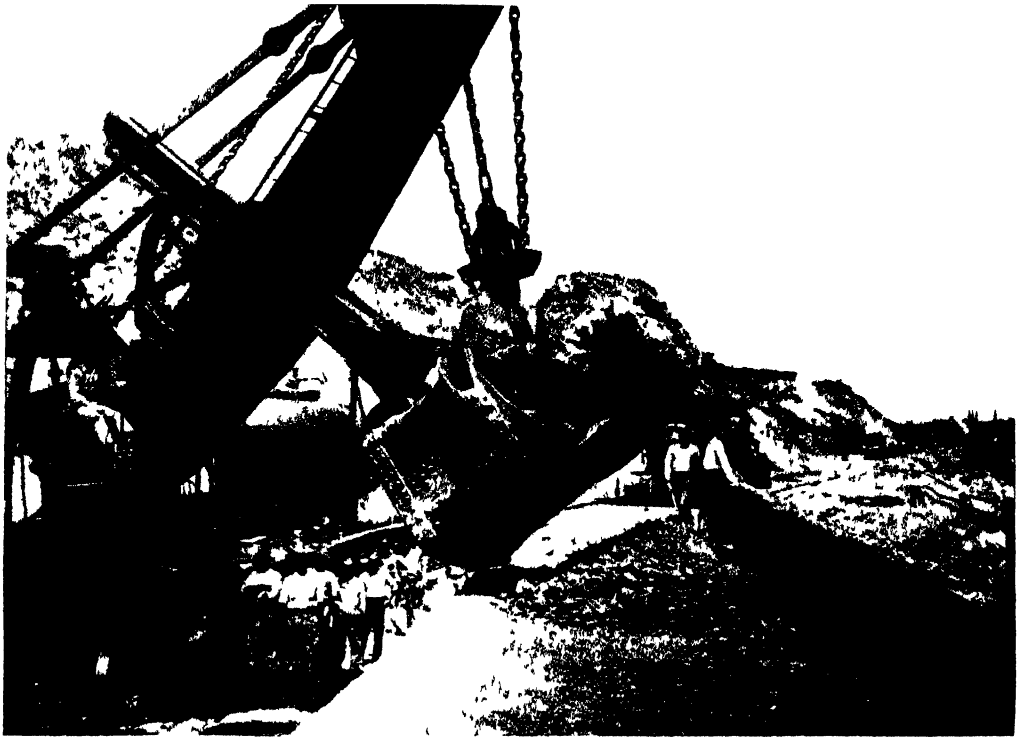
A somewhat similar capturing of waterways by a plant has occurred in the United Kingdom. About sixty years ago the Canadian water-weed was introduced into this country. So rapidly has the plant increased that there is scarcely a river or stream in the land where the Canadian water-weed could not be found, and all this in the span of one man's life! Many of our canals and smaller rivers are practically choked with the weed.

Aggressive Visitors

In some parts of the world the newcomers prosper so exceedingly that they drive out the indigenous vegetation altogether. In many districts of South America the common British weeds, such as shepherd's purse, nettle, and dock, are rapidly killing off the wayside plants of the district. The visitors seem to be quite free from restraint, for they grow to an immense size; thus the ordinary nettle will run up to the height of ten or a dozen feet.

The way in which these weeds seem to be increasing, is causing the greatest concern to the farmers. In one little corner of the world the conquest of new-comers appears to be complete, for it is said that in St. Helena the native vegetation has practically disappeared before the aggressive visitors from Europe.

I.—On the Land: Artificial



A Steam Shovel at Work at Panama

The Romance of the Panama Canal

A Waterway which Cuts a Continent in Two

By E. A. BRYANT

Author of "The New Self Help"

NORTH and South America are no longer one undivided continent. Water flows between them. The dream of ages has come true. North is North and South is South, and never again (if engineering skill may prevail) the twain shall meet. Difficulties have been vanquished, and ships have passed through the long-projected Panama Canal. The seaway of a myriad dreams has become a reality. The Panama Canal furnishes the navigable way through the very neck of the continent which all the early adventurers sought. It was Balbao, not the "stout Cortez" of Keats's version, who, in 1513, was the first European to see from ocean to ocean when—

> " . . with eagle eyes
> He stared at the Pacific—and all his men
> Look'd at each other with a wild surmise—
> Silent, upon a peak in Darien."

On the east lay the known Atlantic, westward, and rolling far, lay the mysterious great South Sea, not to receive its name of Pacific Ocean until Magellan afterwards passed into it. It was but half a century after Balbao that the lion-hearted Drake, climbing a tree at the summit of the isthmus, sighted first the familiar ocean and then the new; and of the latter, with a touch of that romantic enthusiasm which seemed ever to redeem all his faults, "besought Almighty God of His goodness to give him life and leave to sail once in that sea in an English ship." But, try as they might, voyageurs and explorers could find no way through the tantalising isthmus which divided ocean from ocean. All westward geographical investigations of magnitude for centuries afterwards, even to our own day and generation, have consisted of attempts, up and down both coasts, to force a channel through the continent, at some point where climatic conditions were favourable.

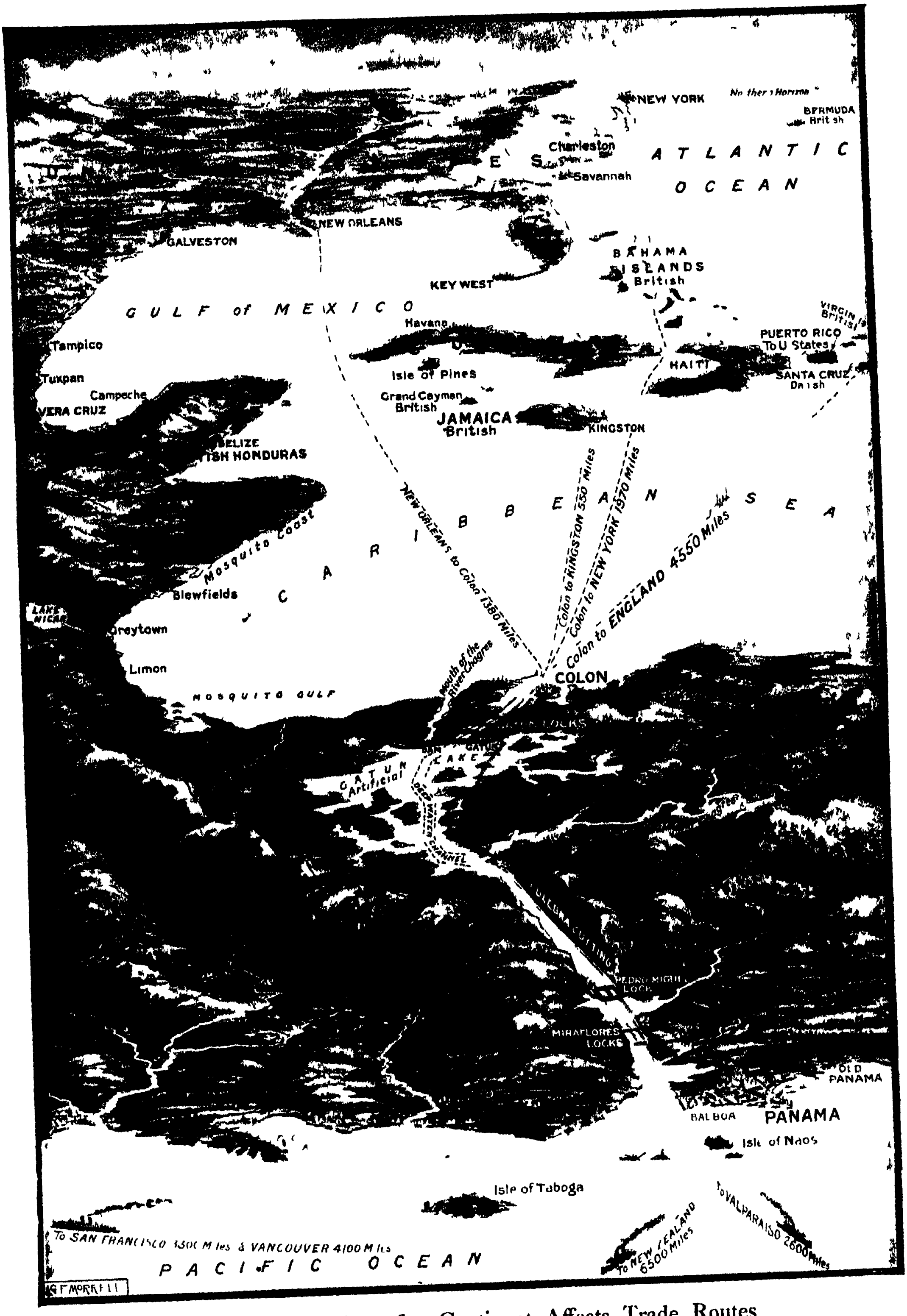
Death to the Mosquito

Spraying trenches with kerosene oil to kill the malaria mosquito and ruin its breeding grounds

In the end it became recognised that the only way through must be cleft by the hand of man; Nature had provided no definite practicable way. One might round the hateful Cape Horn in the South, or take the chance of being frozen in among the ice-fields into which one of Mr. Stefansson's ships was recently blown by a gale raging northward from the land. There remained no alternative to gnawing a way through the neck or waist of the continent—call it which you will. The story of the schemes devised and plans worked out on paper constitutes one of the longest chapters of the great wave of expansion and development in the whole romantic history. De Lesseps was, of course, the first man really to undertake the Panama Canal proper, and a dismal ruin he made of it. He lost fifty thousand lives through malaria and kindred ills in the Canal zone; he brought governments to wreck, thousands of families to beggary, caused an expenditure of a hundred millions sterling, landed himself and many of the directors of his several companies in gaol, and left—a gigantic scrapheap of machinery, and many a charnel house filled with dead men's bones.

The scheme began as a glorious dream; it ended in the direst tragedy that the history of engineering has ever witnessed. All that the shareholders reaped after many years of waiting was a paltry 11 per cent. on the least and most emaciated of the series of companies and that dividend was derived from the eight millions sterling paid by the United States Government for the whole rights possessed by the older companies.

It really seems an amazing thing that the Americans did not earlier think of making an American canal on American soil by this route. When they did, they lost small time in effecting a revolution in more senses than one. They desired not merely the actual route of the canal, but a clear zone, an area five miles broad on either side of the waterway, which area was to be as much under United States control as the most zealous Congressman could desire. Colombia had the right to



How the Bisection of a Continent Affects Trade Routes

(Drawn by G. F. Morrell)

This wonderful "short cut" brings Liverpool and San Francisco roughly 6,000 miles nearer together, shortens the distance from London to Honolulu by some 4,500 miles, and cuts off over 8,000 miles of the voyage from New York to San Francisco treat, but what time Colombia dallied, while the States coquetted with a Nicaraguan scheme, Panama, an integral part of Colombia, broke away from the parent Republic, repudiated its share of the Colombian national debt, and extended the glad hand to the United States. The new Republic had the goods to sell, and could deliver them. It was Panama, the new national entity, which sold the States that which they desired—the Canal zone, with rights and what not—receiving in return two millions sterling, and a further three-quarters of a million extended over nine years. Within a fortnight of the birth of the Republic of Panama a treaty was signed conceding all that the States needed to enable them to do their best from ocean to ocean. Germany, chief creditor of Colombia, is supposed to have caused Colombia to make the fatal delay.

Now came the real trouble. With the enormous zeal of successful Americans, who hold it better to have tried and failed than never to have tried, they began with no very definite scheme save to "make the dirt fly," as the then President Roosevelt put it. But to what purpose was the dirt to fly? The isthmus of Panama is not simply a level stretch of sand. The Canal begins at Colon, on the Atlantic side, and ends, approximately, at Panama, on the Pacific side. Between these two points stretched what Gomara, a seafaring adviser of Philip II., of Spain, described in the sixteenth century as "many mountains." The so-called mountains do not exist, but in their place considerable hills are realities indeed. And through these hills the Canal had to take its way. The Americans began with two huge mistakes. They thought they could cut a sea-level canal for £24,000,000, upon slightly better plans than those which had crumbled beneath the touch of the French companies. The French had excavated over 80 million

One of Many Obstacles

A landslide of 300,000 cubic yards in the Culebra Cut on August 21, 1912

The Making of the Panama Canal

At a cost of roughly £80,000,000 the Panama Canal opens the long sought short cut bringing together the famous ports of the world, shortening the distance between some of them by over 9,000 miles.

cubic yards of material, and had done wonders, all things considered; the Americans were swiftly to do the rest. They were to "make the dirt fly and get the old canal through."

But at the end of the second year of the undertaking, instead of men flocking in to labour as increased demand for muscle arose, a strange silence crept over the zone. Men ceased to work; they lay in hundreds, dead and dying; others were fleeing the area for their lives. The plain fact was revealed that the disaster which had overtaken the personnel of the old undertaking was gathering force for an equally lethal descent upon the new. Mosquitoes stood between mankind and a dream of four hundred years. Malaria and yellow fever were rampant in the encampments. A wise man may make a blunder; a wiser is needed to admit and remedy the error. Here the Americans acted with exemplary wisdom and courage. Every single man of a force of something near twenty thousand was ordered to "down tools," as the new phrase is, and convert himself into a public officer of health. Instead of making the dirt fly they were ordered to prevent the mosquitoes from doing so. Engineering came to a standstill while the men of science marshalled the swarthy sons of toil into brigades of life-savers. This is no wanton digression, for the whole history of the Canal hinges upon that stoppage of work that a crusade might be started. They had taken things as they came, and men had died like flies in autumn. Now they made health the first consideration, for themselves and for the thousands later to join them. They made fly-proof resting-places; they drained places in which the mosquitoes breed; they installed modern drainage; they expelled fever and pestilence, by the only magic effective against such ills—the magic of organised scientific toil. Yellow fever vanished completely with the stegomyia mosquitoes; malaria, which had been claiming for treatment—or interment—over 800 per thousand of the employees, was reduced to astonishingly low proportions, which declined more and more

Drills at Work in the Culebra Cut

as work progressed, until the isthmus, formerly one of the most terrible death-traps in the world, became as a health resort.

Carrying Ships Upstairs

This change was accompanied by an alteration of plans correspondingly startling in design. It was found that the work of cutting through and securing the rotten rock and drifting soil necessary for the execution of a sea-level canal, was impossible. So a complete right-about-face was effected. It was determined, instead of floating the ships of the world on a dead level line from one ocean to another, to carry them upstairs, as it were, through the hills—carry them upstairs on the one side, carry them downstairs on the other side. And that is the plan which has been carried into execution. Water-level in the highest reaches of the Canal is 85 feet above the level at which it was intended to construct the Canal.

To effect this mighty undertaking the engineers had to capture the River Chagres, dam it, and convert it into a vast artificial lake. The ships climb up into this lake and pass, along the highest stretch of the Canal, through its waters. Hence the familiar phrase, the " wedding of two oceans " has no meaning. There is a link —a fresh-water link—between them, the lake formed by this river, which from time immemorial has run into the Atlantic unfettered. The work already done by De Lesseps and the Americans was happily not wasted with the change of plan ; something would have had to be done with the river which, in the rainy season, extending over three parts of the year, would have played havoc with official calculations as to the surface of a sea-level canal. Let us, then, attempt to get the nearly completed scheme in terms which the least skilled in engineering details can grasp.

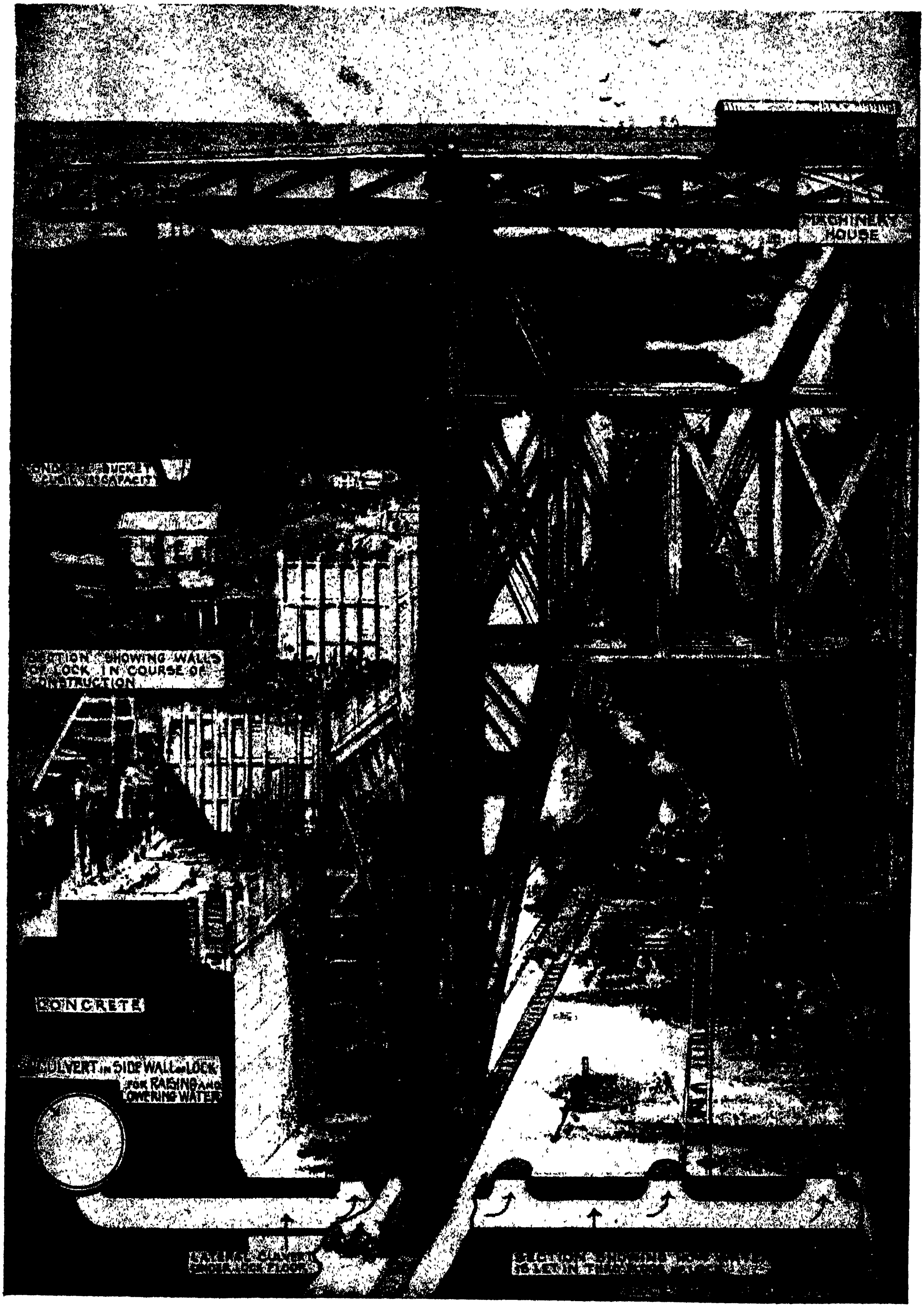
We enter from the Atlantic a deep seaway, protected both north and south against storms, against the dangers of sand carried in by the tide, and from the pranks of the trade winds. Limon Bay is the point of entry, and after a sail of six miles we reach the Gatun Locks, which, bearing the same name with the dam, with which it is not to be confounded, forms, with the dam, the greatest example of engineering of its kind in the world. Here they had to chain a river which, in time of flood, rises 40 feet in a day and night ; confine it so that in the worst of deluges it should always be under control to furnish the locks by which the ships climb, and to supply the little inland sea through which, after clearing the locks, they sail. And all at a height of 85 feet above sea-level !

As to quantities, let it suffice to say that of the 5,000,000 cubic yards of concrete used on the Canal no small proportion finds, let us hope, a permanent abiding place in the foundations of the great dam and locks. The foundations here are 30 feet below sea-level ; and ships will ride close upon a hundred feet above those foundations. This, of course, takes no account of the vast masses of ordinary " filling " employed. Here, then, is the river become a lake, and we must climb upstairs to it.

Colossal Locks

This feat is effected by the colossal locks, the finest locks ever devised. The story of their construction, of the utilising of little hills that were once great hills before the Chagres cut passages along their sides, and sliced their heads off, will some day form the subject of an engineer's book. For us it will serve to notice that they consist of three pairs of twin locks, each 1,000 feet in length, 110 feet wide, and 48 feet deep on the sills. These will take the biggest ships of war or commerce in the world.

A ship, entering at sea-level, proceeds step by step upstairs, and, having completed the third flight, enters the artificial Chagres lake—a lake over 28 miles in length, along the whole of which the ship


MACHINERY HOUSE
SECTION SHOWING WALLS OF LOCK IN COURSE OF CONSTRUCTION
CONCRETE
CULVERT IN SIDE WALL OF LOCK FOR RAISING AND LOWERING WATER
LATERAL CULVERT UNDER LOCK FLOOR

How the Colossal Locks were Constructed

(Drawn by Harold Oakley)

The three pairs of twin locks (each 1,000 feet in length, 110 feet wide, and 43 feet deep on the sills) are the finest ever devised. This drawing conveys an idea of the mode of construction

may steam at speed. The Chagres lake brings our ship to the ill-famed Culebra Cut, which has a length of 9 miles and a width of 300 feet. The cut is simply a mass of rotten rock, shifting clay, and trembling earth. As the "divide" has been made, the unsupported sides have simply slid forwards and inwards, carrying away all before them, overthrowing railways, burying men, smashing steam shovels, causing the bed of the Canal to bulge into hillocks, filling up the parts that have been dug out. Millions upon millions of tons of material for whose removal there had been no estimate have fallen from the sliding, heaving sides of these great earthy glaciers. Rain, acting upon the soil, excessive pressure upon the sloping sides, the havoc of dynamite, the utter instability of the entire formation—these and other causes have gone to the heart-breaking history of the Culebra Cut, the Nemesis which attends the early efforts of the insurgent sons of Nature who seek to override her age-old formations.

The Culebra Cut

Perhaps it does not convey much idea of quantities to state that the landslides and falls in the Culebra represent over 22 million tons, but it may help to realise the amount when we say that the material represents a pyramid having a four-sided base of 1,350 feet and rising to a height of nearly 900 feet. Be that as it may, through this infamous cut our vessel sails some nine miles to Pedro Miguel, where it is lowered 30 feet, and sails nearly a mile through Miraflores Lake, at the end of which are the Miraflores locks. It is interesting to note at this point that while at the Atlantic end steel piles had to be driven in triple rows further to secure the locks and dam after the work was believed to be complete, here at Miraflores we have another example of the utter instability of the soil. The locks were begun originally three miles farther out towards the sea, but after work of enormous cost had been undertaken the foundations were discovered to be so unstable that the work had all to be abandoned and the site at Miraflores adopted. Here our ship makes a descent in two jumps of a little over 27 feet each, down to sea-level, and then, hey! at the end of eight miles, for the wide Pacific. That is the journey. It has already been made. The water runs right through the canal, there remains not a single link unblasted.

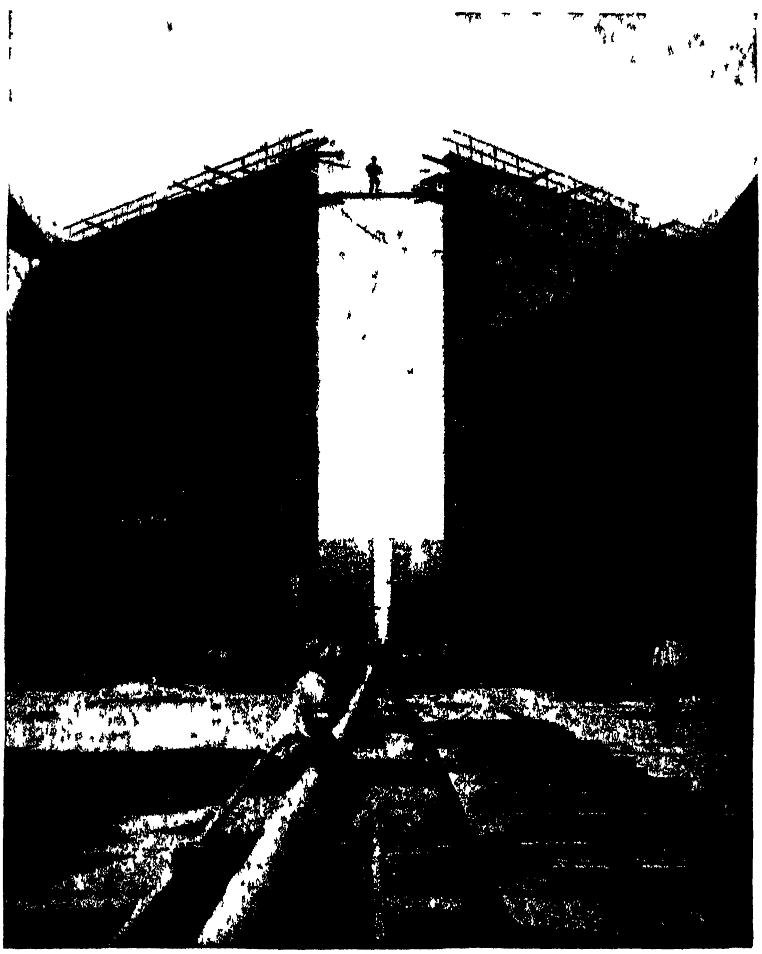
"The real value of the Canal is still a matter of conjecture," as a writer in "The World We Live In" says. "That it will bring about far-reaching changes in the general directions of the streams of world-traffic there can, of course, be no doubt."

It is the biggest thing done by the people who are not reluctant to be considered the greatest nation on earth. That it will be immediately successful only an American would dare assert. We do not yet know what will be the effect of water upon the Culebra Cut.

The water admitted should nearly balance the quantity of rock and earth excavated, but manifold dangers have yet to be combated. The water, which should be a safeguard, may simply disintegrate the already porous rocks and bring down further alluvial avalanches. The inevitable incline of the banks may be fatal to the stability of the cutting. Experienced engineers who know this type of formation, who have worked upon it in many parts of America, declare that there is but one safe level for it, and that a dead flat level —that under no other condition can you stay it. And so the engineers pray for a swift growth of vegetation to bind that which their expert hands have failed to tie. Even the excavators, who have beaten all records, with such figures as 28 million tons of matter removed in the course of a year, may be unwilling to undertake much more, though they will be employed for years to come—in diminishing

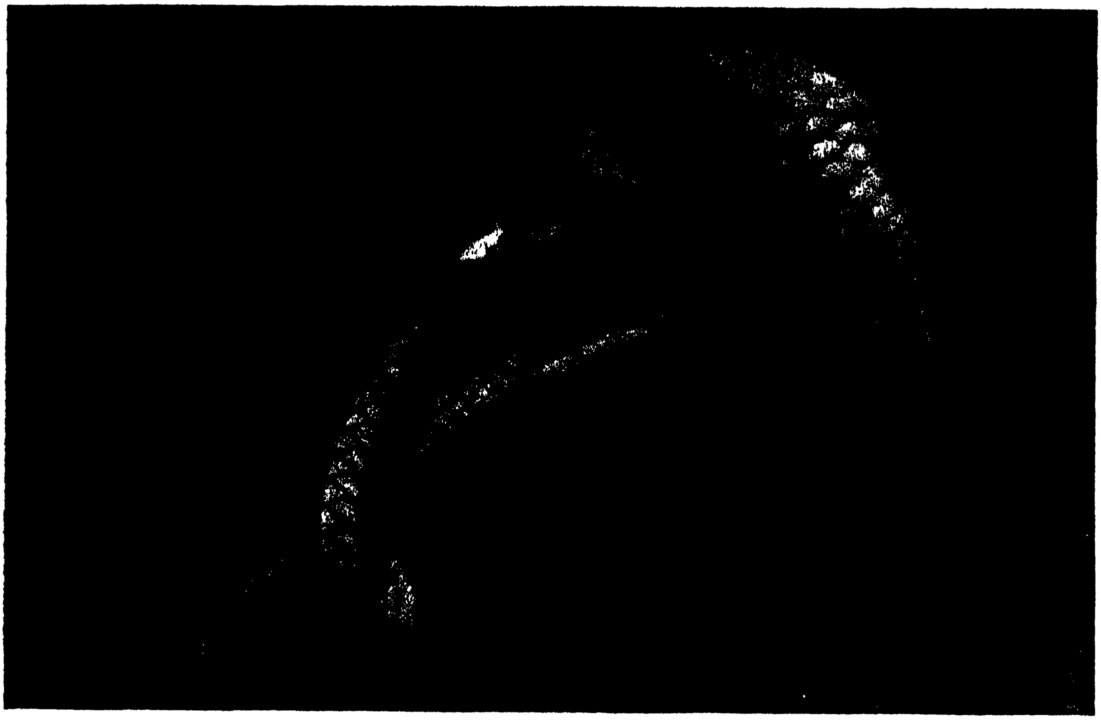
Manifold Dangers

numbers, of course—upon the banks of the entire canal. But already they can point with pride to the fact that the stuff they have removed, if placed in trucks, would form a train encircling the earth four times; that the mere bore-holes they have driven for dynamite, if placed in a line, would pierce the earth from side to side; that their work would dig a canal 55 feet wide and 10 feet deep, reaching right across America from San Francisco to New York, or raise a Chinese Wall 2,500 miles long instead of the 1,500 miles of the Celestial structure, whose ramparts created such a far swaying of wild, nomadic peoples as to cause an eddy to reach across Europe and bring Alaric thundering at the gates of Rome.



The Mighty Gates at Gatun Lock

The work, when all the bills have been paid, will be found to cost the United States not far short of £80,000,000. To her it means aggrandisement, greater commercial wealth, and the shortening of the sea distance between her eastern and western ports by several thousands of miles. Some of the alterations in the sailing distances of the world will, indeed, be very striking, and effect an enormous speeding up in the conveyance of traffic between various ports. Some of these differences are noted on p. 867. The saving of 6,000 miles in the voyage from Liverpool to San Francisco, for instance, will be a notable advantage from a British point of view. But America gains vastly more. At present an American ship, sailing from New York to San Francisco, covers over 18,000 miles; the Panama route will reduce the voyage by over 8,000 miles. The greatest cut of all, however, is in the voyage between New Orleans to Vancouver, which, 14,575 miles at present, will be lowered by nearly 9,100 miles. The Canal opens the long-sought short cut, bringing together at a leap the famous ports of the world and realms which Cæsar never knew.



Photos: W. S. Berridge, F.Z.S.

The Pangolin

Armoured Excavators

Some of the Strangest Members of the Animal World

By W. S. BERRIDGE, F.Z.S.

TO ensure at least a certain degree of safety, all living creatures are given the means of self-defence; but the nature and degree of their powers in this respect vary considerably with different animals. Some rely largely upon fleetness of foot, others upon a highly developed sense of smell or hearing; whilst the more specialised are clothed in a protective covering that may take the form of spines, sharp quills, horny plates, or an outward covering of shell. Many of these add further to their safety by excavating burrows wherein to hide in case of need.

Amongst the latter class the numerous species of porcupines are all characterised by the possession of a spiny armament. The crested or common porcupine, however, has this feature more highly developed than any other. Its spines or quills vary in length from 6 inches to as many as 16 inches, and are boldly marked with alternate black and white rings. Owing to their distinctive colouring they are in much demand for the decoration of native head-dresses, and in this country are used as penholders and fishing floats.

The porcupine carries at the extremity of its tail a very curious rattle composed of a number of horn-like and tubular growths. When alarmed or annoyed the animal vibrates these, causing them to knock against each other, and produces the familiar rattling sound that acts as a warning to all within hearing. Normally, the quills of a porcupine lie in a more or less sloping direction along the body; but, when about to attack, the animal raises them on end by contracting the muscles of its skin. When attacking, the porcupine rushes backwards towards its antagonist with considerable speed, and endeavours to teach it a few home truths as regards the piercing qualities of its armament.

As the quills are only loosely attached to the skin, it is quite true that some at times become dislodged, and are even shot through the air as the animal rushes at its enemy. This fact is doubtless responsible for the mistaken conception as to the porcupine's powers as an "archer."

The common porcupine is nocturnal in habits, and passes the day in slumber within the safe retreat of an underground burrow, which also serves as a home for the young. Its food consists of various fruits, roots, leaves, and the bark of trees. Except during the pairing season, the animal prefers to lead a life of solitude, but at the approach of spring it goes forth in search of a mate. A nest composed principally of leaves and grasses is prepared within the burrow to serve as a warm and soft bed for the young ones. The babies, of which from two to four are produced in a litter, have their eyes open at birth, and their bodies clothed in small and soft quills; these, however, quickly harden and grow apace. Porcupine flesh is much esteemed by the natives of their habitat, and the leopard also regards it as a toothsome morsel and quickly manages to overpower its victim by a blow of its paw upon the head.

Amongst the insectivora there are several species endowed with a spiny covering, and the hedgehog is a familiar example to be found in the British Isles.

A somewhat similar creature to the foregoing, known as the tanrec, makes its home in Madagascar. Although it can only boast of a length of some 16 inches, yet, nevertheless, it holds the distinction of being the largest of the insectivora order. During the months of May or June the tanrecs excavate burrows, wherein they lie in a torpid condition for a period of about six months.

The Tail of a Porcupine

Few animals are more remarkable than the spiny-covered echidna—an inhabitant of Australia and New Guinea. It belongs to a class of creatures known as *Monotremata*, and although it suckles its young in the true mammalian manner, yet these are produced, curiously enough, in the first place from eggs.

The Echidna's Habits

There is an entire absence of teeth in the flattened and beak-like snout, and a tiny mouth is situated at the extreme end—just large enough to allow free movement to its long and whip-like tongue, and enable it to lap up the ants upon which it feeds. The echidna is entirely nocturnal in habits, and hides up in holes during the daytime. It is an expert in burrowing, and makes use of its powerful claws to such good purpose that it can quickly conceal itself beneath the loose sand of its habitat. From all accounts, however, the creature does not bury itself head first, as most burrowing creatures do, but sinks down horizontally by scraping away the sand from underneath it with the aid of its feet.

Only one egg, about the size of a sparrow's, is laid at a time, and this the parent places in a temporary pouch formed merely of a fold in the abdominal skin. In this snug retreat the young one develops until its fast-growing spines render it unsuitable as a pocket companion. It is then turned out to shift for itself.

The common echidna is about one foot in length, but a much larger species, known as the proechidna, and characterised by its more upstanding gait and long, curved snout, is to be found in New Guinea. A pair of these animals, the first of their kind ever to be seen in Great Britain, are, at the time of writing, to be seen at the London Zoological Gardens, one of which is portrayed in the accompanying illustration.

The pangolins, natives of both tropical Africa and Asia, show a different character to any of the foregoing as regards the nature of their armour-like coating, for this is composed of a number of horny plates overlapping one another, in the manner of the tiles or slates upon the roof of a house. Their feet are armed with powerful claws, used for excavating burrows in the earth and to tear open the hard, sun-baked crust of the termites' nests—or, as they are more frequently called, "white ants'" nests—the inmates of which are quickly lapped up as they rush forth to investigate the cause of their rude disturbance. When alarmed the pangolin has the power to roll itself up into a ball, and in this position the sharp edges of its scales are set on end ready to ward off the attack of any adversary rash enough to try conclusions with it.

South America is the home of some curious creatures known as armadillos. They all possess a bony armament encasing the upper portion of the body, and furthermore the front of the head is also protected by a shield-like cuirass extending halfway down the snout. In some species even the tail and legs are covered with scales.

The body armour is divided into bands, varying in number with the various species of armadillo, and such an arrangement gives a considerable degree of flexibility to their movements that they otherwise would not possess. The limbs are short and armed with powerful claws, those of the fore feet being specially developed and very effective in use when the creature is burrowing.

The Pichiciago

The smallest, and at the same time the most remarkable of this group, is the pichiciago—an animal measuring about five inches in length. Its shell-like covering is of a pale pink colour, and the fur of the under parts pure white and silky in texture. The armament commences just above the creature's nose and extends in a series of bands to the end of its back. On the hind quarters, however, the armour is continued by a solid shield overlaid by thin plates, at the lower end of which is conveniently situated a small notch for the protrusion of the animal's tail. This bony shield is stated to be used as a kind of battering-ram when the animal desires to

Proechidna from New Guinea

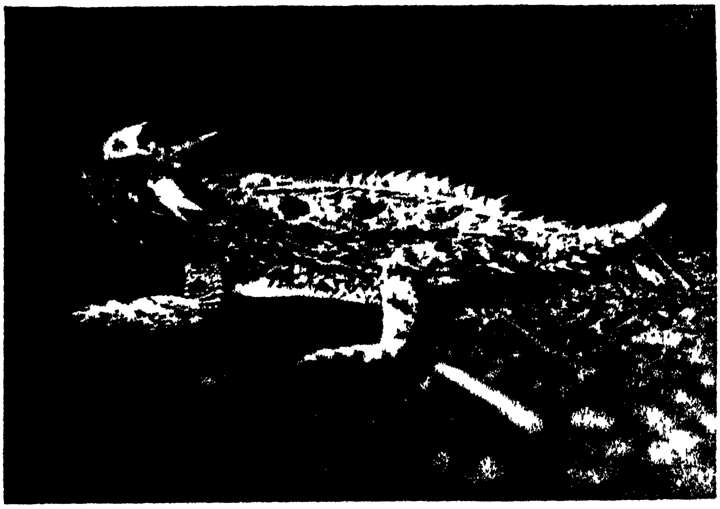
close up the entrance to its burrow. It certainly would prove very effective for such a purpose.

The pichiciago is a very rare animal, and only found in the western part of the Argentine. It has never been imported alive into this country. The animal burrows with such rapidity that, according to the reports of Mr. E. W. White, who was fortunate enough to be able to observe it under natural conditions, " a horseman has barely time to dismount on coming across one before it has buried itself completely out of sight."

Leaving the mammals, and passing to the reptiles, we still find quite a number of species that possess a protective armour. Many of the lizards are completely clothed from head to tail in spines; but even more wonderful, although owing to their familiarity apt to be overlooked, are the tortoises, which may well be described as living creatures encased in strong bone-like boxes. With many tortoises the shell is of a fixed and immovable character, the extremities at either end being left open for the protrusion of the head and tail; but in other cases the shell is hinged and enables the owner to shut up like a box.

The kinixys, or hinged tortoise, has the power of closing one end of its shell by the lowering of the hinder portion of its carapace, or upper shell; but the Carolina box tortoise can do even better than that, for it is able to close both ends at will, the plastron or lower shell being hinged across the middle.

Tortoises may be roughly divided into two groups—namely, the land tortoises and the water tortoises. The latter are, however, by no means exclusively aquatic in habits, but spend considerable time upon land. The former are entirely vegetarian in diet, whilst the water tortoises favour carnivorous food. Unfortunately this important distinction between the habits of the two is not so well known as it should be, for numbers of the land tortoises are sold by street hawkers to unsuspecting house wives as a sure means of ridding their kitchens of black-beetles.



The Horned Lizard

One of the best known of the land tortoises is the Grecian tortoise. It measures, when fully grown, about 10 or 11 inches in length, and is characterised by its upstanding dome-shaped shell. The two sexes are almost identical, with the exception that the male has the undershell slightly concave, whereas that of the female is quite flat.

The jaws of a tortoise are devoid of teeth, but the horny edges are equally serviceable, and can grip things as in a vice. When feeding, tortoises pluck their food to pieces by vigorous jerks of the head, and have the habit of holding it down on the ground under their feet.

Photo Burchell, California

Giant Galapagos Tortoise, 2,000 Years Old

Of the water tortoises the European species may be taken as a typical example. It is easily distinguished from the land tortoise by its flat shell, greater length of tail, and yellowish, streaky markings. In size it does not attain to such large proportions as the Grecian tortoise, and one measuring 6 inches along the shell may be considered a good specimen.

There is a marked difference between the character of the two types, for whereas the land tortoise is slow in its movements and of a very placid disposition, the water tortoise is able to run with considerable speed and knows how to make good use of its mouth for biting. Both undergo a period of hibernation during the cold weather, making deep burrows underground, where they remain oblivious to the wintry elements that may be reigning above. The young of all tortoises are produced from eggs, which the parents usually deposit in a hole scraped out of the sand. They are then carefully covered up again and left to hatch out under the influence of the sun's rays.

The female of the Grecian tortoise lays about ten to fifteen eggs, measuring an inch or so in length. The incubation period lasts for about three months, and when hatched the young very much resemble animated walnut shells.

A remarkable feature in connection with tortoises, and indeed with all reptiles in general, is their extraordinary vitality. They are able to live for months without partaking of any food, apart from the period of hibernation, when, of course, all their organs are practically dormant. It is also a curious fact that a tortoise will continue to move and even walk for quite a long time after it has been beheaded.

Although the majority of tortoises are of small size, yet certain species, known as giant tortoises, prove an exception to the rule. The most familiar of these are the Aldabra tortoises, and those from the Galapagos Islands, which frequently attain to a length of 4 or 5 feet. At one time these giant tortoises were very plentiful in their haunts, but at the present day their numbers are so reduced that they are in danger of extinction at no very remote date.

III.—On the Sea: Natural

The Sea-Horse

By STANLEY C. JOHNSON, M.A., D.Sc.

ONE of the most curious creatures which dwell in English salt waters is the Sea-horse or *Hippocampus brevirostris*. Fierce and eccentric in appearance, this timid and harmless fish makes its home along the shores of Cornwall, Devonshire, and Dorsetshire, around the Channel Islands, and within the rocky bays which fringe the coast of Brittany. It is, of course, also found largely in the southern hemisphere.

Hippocampus is unlike most other fish, as it has an upright and not a horizontal carriage. Its fins are but little developed; instead, it possesses a prehensile tail of unique powers. This tail is wonderfully agile in grasping and holding on to strips of seaweed which are encountered during the animal's progress. It is at once an anchor, a rudder, and a propeller.

But the sea-horse is a poor swimmer; in fact, it is doubtful whether it can make much headway against even a slow current. Probably the tides decide its course almost entirely. In a general way, it may be said that its life is spent in a quiet recess among the rocks, sheltered from the buffeting of the waves and water. In these spots, it enjoys a certain amount of seclusion from the elements, but living foes are numerous. Protection is amply afforded, however, by its fierce and forbidding appearance, and also by its close resemblance to the seaweeds among which it dwells, a point which our illustration aptly portrays.

The sea-horse is a marsupial, the male possessing an egg pouch underneath the tail. The young are carefully guarded and nurtured, and not left to their own resources, as happens with most other fish. The male, it may be added, does most of the "mothering."

Hippocampus is an animal which lives well in captivity. Those of us who are fortunate enough to possess aquaria containing living specimens may note the curious chameleon-like way these creatures have of moving their eyes. These move independently of each other, a fact which enables *Hippocampus* to perform the most weird of facial contortions.

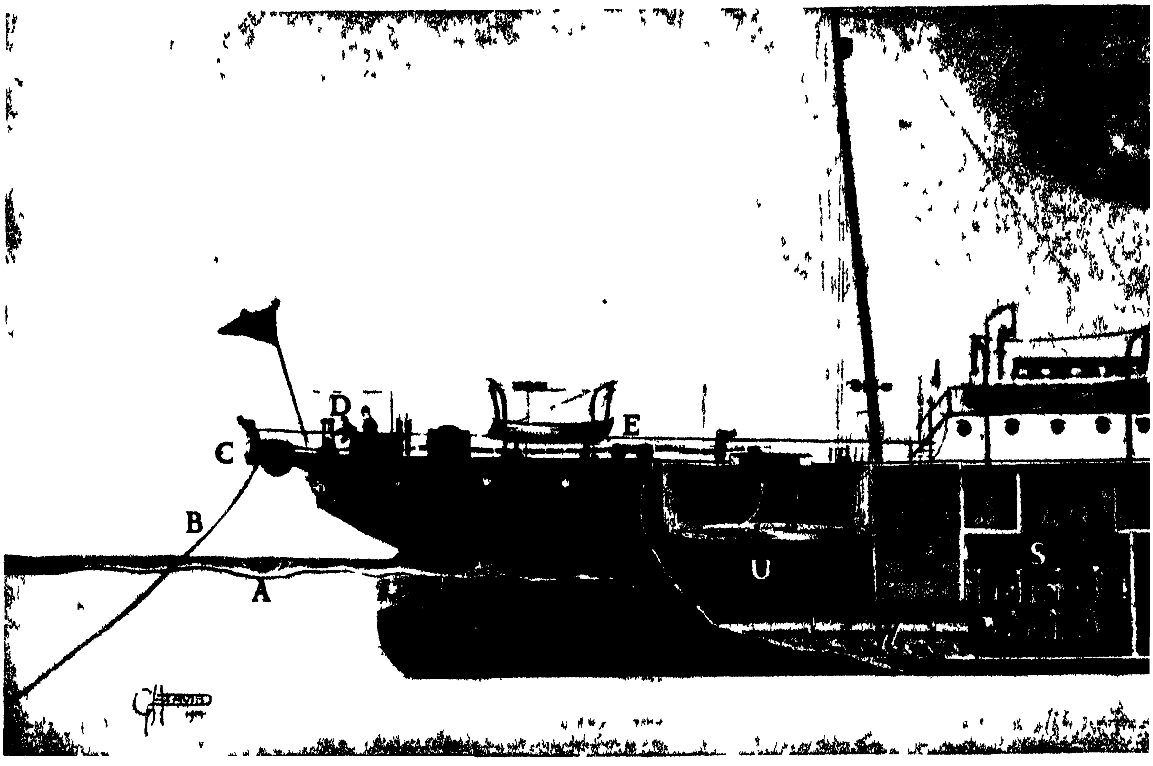
Phot Stanley [illegible]

The Sea-horse (*Hippocampus*)

Its name is probably due to the marked resemblance it bears to the knight in a set of chessmen, but how and why Nature evolved for it so curious a shape is a mystery.

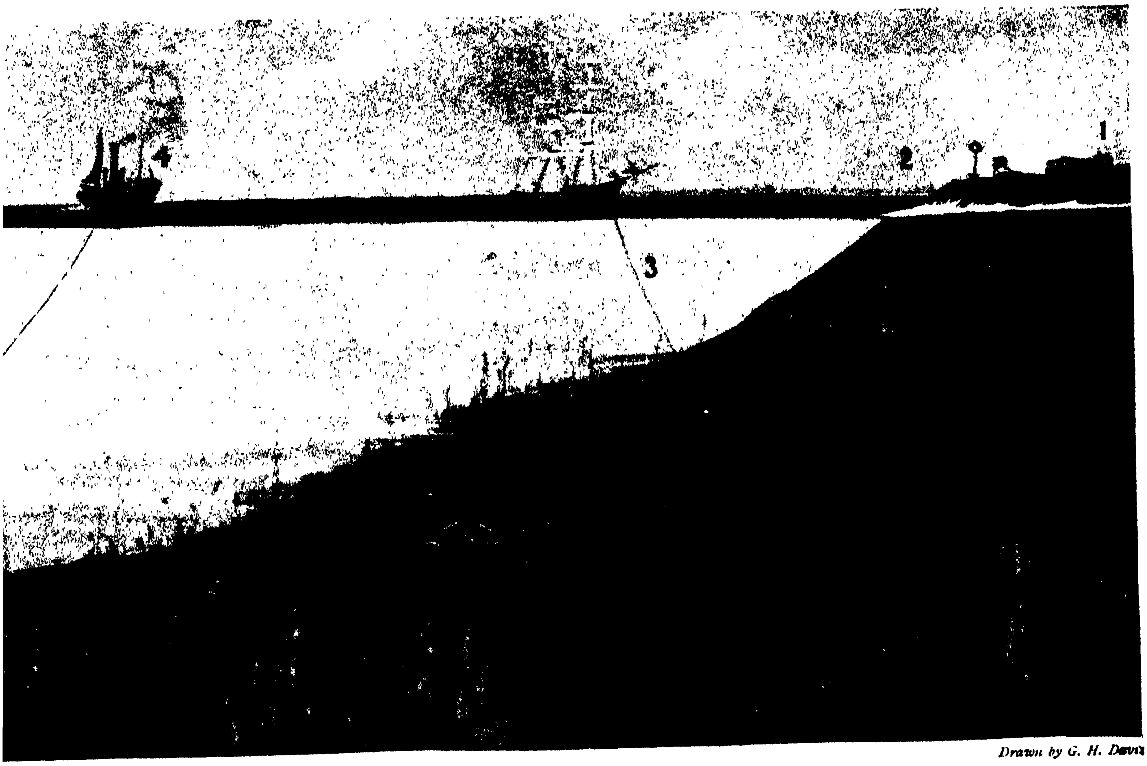
THREE COMMON CAUSES OF SUBMARINE CABL

1. Cable house, 2. Waves and currents, 3. Ships' anchors, and 4 & 5. Trawls, are constantly doing damag



SECTIONAL VIEW OF A CABL

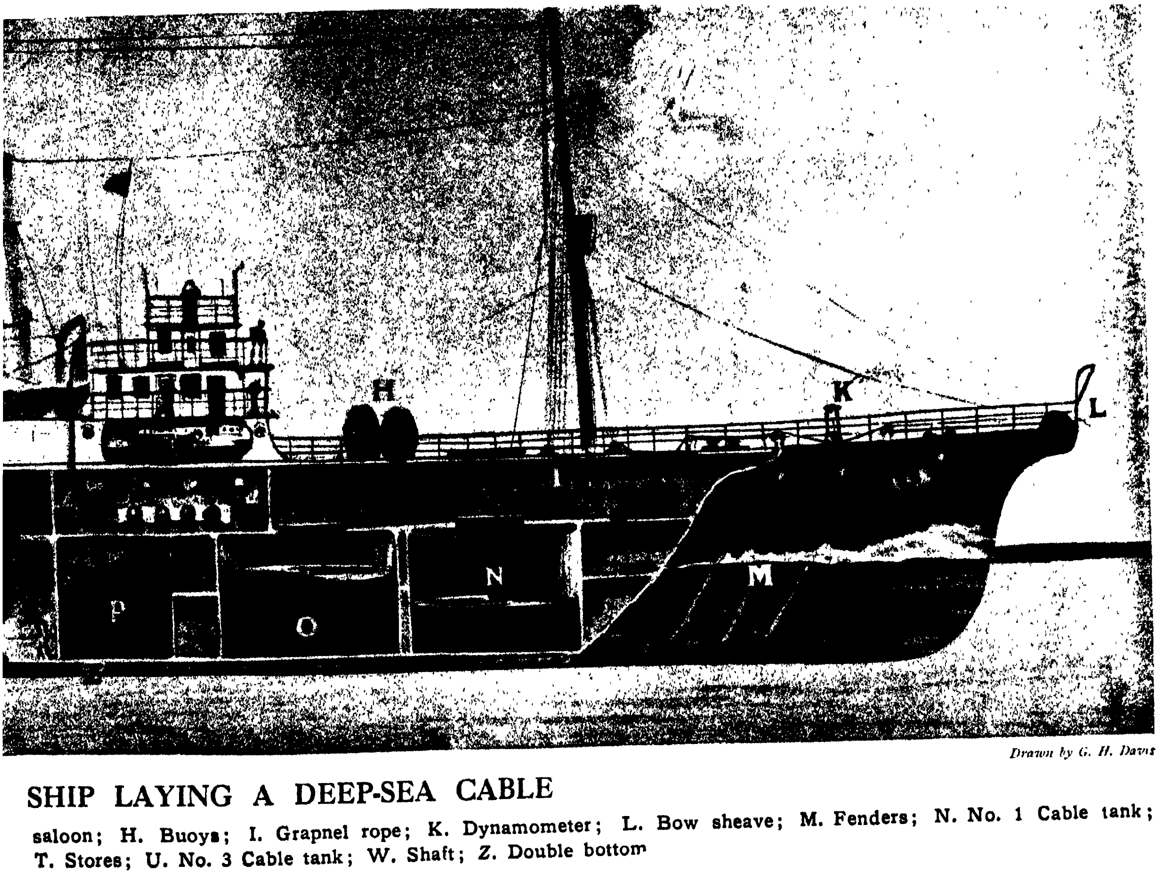
A. Water line, B Cable, C. Stern sheave, D. Dynamometer, E. Retarding wheels, F Testing-room, G. Dinin
O. No. 2 Cable tank, P. Bunkers, R. Boilers, S. Engin



Drawn by G. H. Davis

BREAKAGE BY TRAWL, TIDE, AND ANCHOR

6. Water line; 7. End of cable temporarily attached to mark-buoy; 8. Using grapnel to find broken cable



Drawn by G. H. Davis

SHIP LAYING A DEEP-SEA CABLE

saloon; H. Buoys; I. Grapnel rope; K. Dynamometer; L. Bow sheave; M. Fenders; N. No. 1 Cable tank; T. Stores; U. No. 3 Cable tank; W. Shaft; Z. Double bottom

IV.—In the Depths: Artificial

Photo L.N.A.

The Cable-laying Ship "Faraday"

NOTWITHSTANDING the fact that the rapid growth of wireless telegraphy has produced a serious rival to the submarine cable, these electrical connections, running across the sea-bed of every ocean in the world, carry more messages to-day than ever. They have linked up all the odd corners and out-of-the-way quarters of the world, and have been of incalculable value, not only to the general public, but to the Press.

Important happenings upon the other side of the English Channel, but a few hundred miles away, sometimes took weeks to reach London before the advent of submarine telegraphy; and great events, such as the battles of Quatre Bras and Waterloo, took days to filter through to us. For instance, hundreds of English villages knew nothing of the fall of Napoleon for *months* after the event had occurred.

With the advent of the cable and the telegraph the world outside the British Isles has become but a few minutes distant. Great happenings in all quarters of the globe, divided from us by thousands of miles of sea, are wired in a matter of seconds to our newspaper offices, and appear on the sheets but a few hours (and oftentimes less) after the event has occurred. News items, such as an important test match in Australia, a great strike in South Africa, or an international yacht race in America, are sent through the cables to all parts of the globe.

This wonderful link is, nevertheless, of comparatively modern origin, and it is not yet sixty years ago since the first Atlantic cable was successfully laid after a series of costly defeats, which on one occasion meant the total loss of nearly 500 miles of cable. In those early days of the new idea the cable-laying ships would meet in mid-ocean, each carrying a huge length of the cable, and, after having connected their separate cable lengths, would proceed in opposite directions towards either shore, paying out as they went. To-day the cable is started from one shore end. Here it is 6 inches in circumference, covered as it is by its "armouring," fashioned to withstand friction against rocks, anchors, trawls, and the movements of the tides. It tapers to 3 inches circumference in mid-ocean, the weight being reduced to a minimum to enable the cable ships to recover it with greater ease in case of a defect. It must be remembered that these wires are so strongly built up of copper, gutta-percha, outer casing, and "wire armour," that at the shore ends they will weigh as much as 28 tons to the mile. This dead weight, lying fathoms deep in mid-ocean, would practically render repair work impossible when a break occurred.

Cable-laying Ships

To carry out the work of cable-laying special vessels are built, and at the present moment there are over sixty of this class of ship afloat, the larger vessels having a cable stowage capacity of 11,000 tons. They carry a crew, including the electrical, engineering, and navigating staffs, of 150 men. The tanks, wherein is stowed the huge length of wire, vary in size with the capacity of the ship. Many vessels have four of these tanks and carry over 3,500 miles of cable. From the tank the armoured cable passes up and goes over a number of retarding wheels placed to prevent the cable rushing out-of-hand overside; it then goes under a dynamometer that registers the strain, and from thence passes over the great wheels attached to the platform over the stern of the ship and into the sea. The vessel then steams ahead, the cable passing into the water at a speed a knot or so in excess of that of the vessel, to allow for the hills and valleys on the sea-bed; and, with the cable under perfect control, the ship works seaward upon her mapped-out course.

Submarine Surveying

It must be clearly understood that, before the vessel commences to work the cable overboard, the course upon which the wire is to be taken has been very carefully surveyed, as great areas of the ocean bed consist of nothing more nor less than submarine mountain ranges. It is necessary to discover a huge plateau free as possible from ridges, and also free from those submarine hot springs that sometimes occur, which spell short life to the wire passing near them. The surveying vessel accordingly takes numerous samples of the water at the bottom of the sea right along the proposed route of the cable, and, if it is universally found to be very cold, as is usually the case, the work can commence. To illustrate this, we may say that there is a submarine tableland of this description running all the way from Ireland to Newfoundland, a distance of over 16,000 miles, and upon this "flat" the sixteen Atlantic cables have been laid. Had the same wires been taken a thousand miles farther south the great submarine mountain ranges, of which the Islands of Hayti, Puerto Rico, and the Windwards are the highest peaks, would have had to be crossed, meaning a severe strain on the cables and an added length of countless miles.

As the laying-ship steams ahead the great length of cable trails away astern. Gradually sinking in deep water, say two and a half to three miles deep, the cable will be twenty-five miles astern before it comes to rest on the ocean's bed, and nearly three hours will have passed since that given point of cable had entered the water. All the time the electricians have been keeping up a series of tests with the shore end to see that everything is working correctly, for if a defect occurs the work must be stopped at once. If all goes well the great vessel will leisurely steam ahead, never stopping, and with her men working in "watches," until she is within a mile or so of the opposite shore. Next comes the more or less difficult operation of getting the cable ashore, and this oft-times means very strenuous work.

Landing the Cable

Special boats are used to bring the end shoreward until aground, then a large number of men are employed to drag the great wire farther and farther inland, their labours being directed by a skilled foreman who knows exactly how this final operation should be carried out.

This, roughly, is the whole story of how the cable is put down; but there are other jobs that the cable ship has to carry out, and one of the most difficult is the repairing of a break.

Usually this occurs near the shore, either by friction, caused by the movement of the cables swayed by tide and currents and rubbed upon some sharp projection upon the sea-bed, or more often by the anchor of a vessel, or the huge and powerful otter trawl of a modern steam trawler coming "afoul" of its resting place. Occasionally the break occurs farther at sea, and then, in this case, the job is infinitely more difficult. First of all, tests are made from the shore ends to discover the fault. This is done by testing the amount of resistance to the electric current offered by the cable's conductor; the course of the cable is then mapped out on the chart, the approximate position of the break duly marked and given to the captain of the cable ship, who steams away seaward until he comes over the spot where it is imagined the break has occurred. This he duly marks by a large mark-buoy, which is anchored to a many-fathomed length of steel chain.

Then comes the slow but difficult job of grappling, or fishing, for one of the broken ends, which, with luck, may only take a matter of hours, but which, on the other hand, has caused some cable repair ships to spend days and even weeks (on one occasion in the West Indies months) pegging away on this monotonous job, often losing as many as forty grapnels broken in contact with submarine rocks before the cable is at last secured.

It may be asked how the men know when they have "caught" the cable, and this can be easily explained. The grapnel rope before going overboard passes over the pulley wheel of a dynamometer, which measures the strain; also the men are so skilled at the work that an expert can "feel" the rope—that is, by the vibration carried up to him, he can, by sitting on the rope, with his hands pressed upon it, discover by the different vibrations whether the grapnel is passing through ooze, gravel, or rock. When it really catches the cable the pull remains steady, and thus, after endless winding, the broken end reaches the surface. It is here tested and then securely attached to the mark-buoy, which has a lifting power of nearly 7 tons.

The same proceeding next takes place to secure the other broken end, the ship steaming backwards and forwards over the course of the cable until ultimately both ends are safe above the surface. If the second recovered end is found "O.K.," a piece of new cable is spliced to it and the ship then steams back to the buoy, and here the joint is re-made. Further tests take place, and then once more the cable is consigned to the deep. This possibly sounds quite an easy operation; but the work in rough weather, besides being very monotonous, is at times highly dangerous to life and limb.

The Mark-buoy

The laying out of the mark-buoy is often a difficult operation, and when darkness comes on the two lamps attached to the staff have to be lighted and tended, and if a heavy sea is running in mid-Atlantic the man left alone on the buoy to carry out this work has to hold tight for his life, for constantly the seas will wash clean over him. Moreover, the boat work is equally dangerous, and the seamanship must be of the best.

In one day 15,000 words are borne by the world's cables, and great business concerns in all the civilised nations control the various submarine lines. From the first Channel cable put down as an experiment, which never spoke a clear message and was hooked up by a surprised Boulogne trawler a day later, we now have dozens crossing the Channel, and, in addition to these lines carrying the dot-and-dash code messages, we now have telephone lines that carry the human voice from London to Paris and Berlin. In 1910 the famous old cable ship *Faraday*, whose story is mixed up with cable-laying and repairing more than any other in the world, put down another connection twenty-one miles in length, weighing 275 tons. The sending, too, has vastly improved, and from the early stammer of two words a minute we now have the rapid transmission of one hundred words (fifty going each way) in the same space of time.

Great names are linked up with the invention and development of these submarine lines which connect up the whole civilised world. The first Atlantic cable was laid thanks to the genius of Sir Charles Bright. Among other names connected with the work we may mention Lord Kelvin, Dr. Whitehouse, Sir Samuel Cumming, Sir William Siemens, and Faraday.

The romance of the work must appeal to all, and though the cable is threatened to some extent by wireless telegraphy, as we have previously mentioned, it will be many years yet before the cables will be left to rot on the floors of the seas while our messages go through the air transmitted by invisible waves. Both systems have their uses at the present moment, and to-day there is room for both; but undoubtedly with the further development of wireless the cables will begin to lose custom, for the work of laying and repairing (and a small job will cost £200 per day) will keep cable rates so high that they will be unable to compete with "wireless."

Drawn by H [illegible]

Submarine Cable Attacked by Sawfish

However, the cable is of the utmost importance to humanity to-day, and, as an invention, was one of the greatest and most useful that the great savants of the science of electricity ever gave to the world.

The Transmutation of the Elements

Wonders of Modern "Alchemy"

By ARTHUR HOLMES, F.G.S., A.R.C.S.

Author of "The Age of the Earth"

IN all ages, philosophers have been profoundly interested in speculations concerning the ultimate nature of Matter. Throughout the infinite manifestations of existence, embracing stars, flowers, minerals, animals, and man himself, they have sought to find a single fundamental "stuff" in terms of which all phenomena would be readily explained. What is this *Thing in Itself*, this wonderful entity which is the soul of the material universe ? At the outset it may be as well to say candidly that we do not know, and that, in so far as these ultimate questions are concerned, we are groping in the dark like the mediæval alchemists.

The Soul of the Universe

Yet there is no doubt that the conception of the transmutation of elements arose from just such a question. The Alexandrine Greeks believed that all substance was formed of one primitive matter. The obvious differences in things were attributed to different qualities which were superimposed upon the *prima materia.* Honey was sweet because it was substance imbued with the quality of sweetness. The sky was blue because of the presence of blueness. It was hoped, by removing all the qualities of a substance, to get at its soul, the *prima materia* common to all substances. This accomplished, it became a simple matter to add the appropriate quality or qualities, and so produce the desired material.

This daring conception stimulated the early Arabic scientists, and they in turn passed on their ideas to Western Europe. The fundamental substance which men tried, century after century, to prepare, was thought to be most nearly represented by mercury ; but, let it be observed, not vulgar mercury. It was the soul of mercury, the mercury of the philosophers, which the alchemists sought; and even when they had found this elusive substance, it was necessary to purify it by depriving it of the four elements—earth, air, fire, and water—before the Philosophers' Stone was attained.

Roger Bacon

Roger Bacon wrote that with one part of the Philosophers' Stone he could turn a million times as much base metal into gold. He was impressed by the procession of growth and decay in the organic world, and just as animals gradully develop and reach the splendour of complete maturity, so, he thought, metals might likewise do. With such a conception constantly before a superstitious and credulous world, it is not surprising that many unscrupulous men pretended to a success which was purely fictitious. Deception was rampant, and even kings, attracted by the glamour of vast profits, lent their authority to these pretences by issuing counterfeit coins.

It may be of interest briefly to review one of the methods by which the Philosophers' Stone and the elixir of life was said to be prepared.

1. Take pure mercury and purify it again by treatment with vinegar and salt until it is *quite* pure, or almost quite pure.
2. Then mix it with sublimed mercury.
8. Sublime the mixture five times over a sand bath, and a sweet and crystalline

Photo: Dr. Alfred Gradenwitz

Sifting Tanks in an Up-to-date Radium Factory

Radioactivity has started on a victorious career as a new branch of human knowledge. Only a rash prophet would set bounds to the possibilities that may follow when scientists have learned to control its energies

sublimate will be obtained. This constitutes the salt of wise men, and has wonderful properties. It must now be reduced to powder.

4. Prepare spirit of wine until it is so pure and volatile that a falling drop will evaporate before it reaches the ground.

5. Cover the powdered salt of wise men with the pure spirit, and seal in a retort. Heat gently for seventy-four hours. Then distil and add more spirit of wine until the spirit of mercury mingles with it.

6. The spirit of wine must now be distilled from the spirit of mercury by very gentle heating. The quintessence, or soul, of mercury then remains, no longer vulgar mercury, but the mercury of the philosophers. It is now fitted to receive the tinctures of gold and silver; it is the fountain in which the king and queen may bathe. If this stage has been attained, the patient worker must retire to his chamber and thank God for the success which has attended his labours.

The Philosophers' Stone

7. The Philosophers' Stone is now at hand. Take a few purified grains of philosophical gold, and marry them to the quintessence of mercury until they are completely dissolved. Presently, the water will be converted into earth, and peace will reign between water and fire. The gold is now a most noble clarified earth, by which metals may be turned into the most pure gold, and which possesses the energy of curing all diseases. Return thanks to God for bringing to a successful issue and rendering fruitful all these labours.

The transmutation of the elements was a commonplace idea so long as the qualities of things were looked upon as all-important. The production of brass from copper was a partial case of transmutation, for one quality of the copper had clearly been changed to the corresponding quality of gold, namely, its colour. Similarity was mistaken for identity.

Nature's Bricks and Cement

With the advent of our modern chemical conceptions, the idea and possibility of transmutation began to fade away and to seem so improbable that its philosophical basis was largely lost sight of. Transmutation came to be regarded as the greatest of scientific heresies. Before the discovery of radioactivity, there were known to be about eighty elements, each of which was regarded as a fundamental substance, incapable of being transformed into any other element. Thus oxygen, gold, and sulphur were and are regarded as elements, because all the attacks which the chemist and physicist have made upon them have failed to resolve them into anything simpler. As Soddy has very picturesquely said, the compounds of Nature are built up with bricks of elements and cement of energy. The elemental bricks which make up a piece of sugar are oxygen, hydrogen, and carbon. This can be proved in the simplest way. If a piece of sugar is heated water (a compound of oxygen and hydrogen) is given off, and a black mass of charcoal remains behind.

The smallest quantity of each element which can exist is called an *atom* of that element, a particle so small that it cannot be further subdivided by any of the means at our disposal and yet remain as a recognisable form of the original element. In general, atoms do not exist alone. They show a strong tendency to unite with one another, at the first opportunity, to form molecules. A molecule is the smallest particle of any substance which can exist. If a molecule of water is divided into still smaller particles the latter are not particles of water, but the atoms of hydrogen and oxygen, which by their union form water.

Each atom of the same element has a definite mass in which it unites with other atoms of equally well-defined masses. Thus the fundamental characteristic of an element is its "atomic weight." It was found, fifty years ago, that if the elements are written down in the order of their atomic weights each element differs in a most marked way from its immediate neighbours, just as do the notes in a musical scale. However, the eighth element shows a strong family resemblance to the first; the ninth to the second, the tenth to the third, and so on. The general properties of the elements were thus found to be repeated in octaves, just as the notes on the piano repeat themselves again and again in octaves. This arrangement of the elements is known as the periodic classification, and has proved itself to be of the greatest value as a chemical concept. Its inner meaning and significance are still obscure, but in a confused sort of way it suggests that the elements are not the thoroughly independent entities they were originally considered to be. The interrelations and analogies between them betray the fundamental unity which underlies them; but the riddle is still unsolved, in spite of the years of strenuous labour which have been devoted to its elucidation. At the close of the last century, in spite of the vast number of speculations which had been made and tested, no artificial change of one element into another had been found possible.

Periodic Classification

Radioactivity, however, had already started on its victorious career as a new branch of human knowledge. Certain heavy elements, like uranium and thorium, were discovered to have the remarkable, and at first almost incredible property, of breaking down into less massive elements, all of which, with two exceptions, had previously been unknown, owing to the tiny quantities in which they exist. Radium, for example, is constantly being formed at the expense of uranium and the chain of elements by which it is connected to its ultimate parent. In turn radium breaks down into lead through a still longer chain of daughter elements. Thus, only a small quantity of radium ever exists at one time, for as fast as it is formed by the transformation of its heavier atomic ancestors, it decays into its lighter atomic progeny, leaving at last an accumulating residue of lead. The difference in atomic weight between lead and uranium is accounted for by the expulsion, with explosive violence, of atoms of helium all along the line.

The question now arises whether these extraordinary changes are to be regarded as transmutation. In so far as that term implies a change accomplished by human agency, it is certainly not applicable, for nothing whatsoever that may be done to the radioactive element affects its regular, apparently unalterable, rate of decay. We now know that from our new point of view the atom is no longer indivisible. It is like a tiny universe of inconceivably small particles, a whirling assemblage of electrons in a halo of positive electricity. These, and not the atoms, are now to be regarded as the foundation stones of the material universe. In general, the internal energy of the atom is locked up; but in the radioactive elements the structure is unstable, and from time to time some of the energy can escape, and a new atom, more or less stable, simultaneously makes its début.

But whether we try to excite these unstable atoms by exposing them to the highest temperatures which can be attained, or whether we try to drown their energies in a bath of liquid hydrogen, they care not; bombarded by their own radiations, penetrated by swiftly-moving electrons, subjected to the violence of the most terrific explosions, they do not perceptibly change in the steady onward march of their disintegration. Thus, in the significant sense of the word, transmutation is not exemplified by the radio-elements. Perhaps, in the future, we may be able to control the internal atomic energies which would be liberated by transmutation, as Mr. H. G. Wells has

Internal Atomic Energies

suggested in his most recent scientific romance.

A Reservoir of Mighty Energy

How important the human control of these natural processes would be, is strikingly illustrated by the fact that 1 lb. of uranium contains within itself as much energy as could be obtained by the burning of ten million tons of coal.

Now, if we are unable to vary in an artificial way the natural period of disintegration of the radioactive elements, which are already unstable and predisposed to transformation, it would seem that the possibility of effecting the transmutation of the ordinary elements is even less remote. However, for the last six years Sir W. Ramsay has performed experiments in which he claims to have observed the appearance of elements which were not previously present. He obtained lithium from copper, and carbon-dioxide from silicon and oxygen. Then, as recently as February, 1913, he described a series of new experiments in which some of the rare gases of the atmosphere—neon, for example—were detected in apparatus from which they were thought to have been originally completely expelled.

Professor Collie and Mr. Patterson obtained similar results by a somewhat different method. When an electric discharge is passed through a gas at very low pressure, rays consisting of swiftly-moving electrons are emitted. This was done in a tube of low-pressure hydrogen and helium, and neon appeared in such a remarkable manner as to satisfy Mr. Patterson that these elements had been produced from substances in which they had not previously been present.

As to the origin of the gases, there is at present much controversy. Two facts, however, should be carefully remembered. If other gases than hydrogen are used for the passage of the electric discharge, then the relative amounts of helium and neon are found to vary. Moreover, the gases cannot be liberated from the materials of the apparatus even by the most intense heating.

Sir J. J. Thomson also has conducted similar experiments, and he finds that when the action has progressed for a considerable period, the liberation of the new gases ceases altogether. These curious phenomena are at present quite unrelated to any of the properties of matter hitherto described, and it would be rash to decide either for or against the realisation of the long-looked-for transmutation of the elements. As an alternative explanation to transmutation, it has been tentatively suggested that ordinary elements may be faintly radioactive. They may, perhaps, disintegrate so slowly that the helium (or even neon) which is liberated by their natural decay has insufficient energy to break away freely from the parent atoms. If this were so, it is possible that while heating would be without result, yet the bombardment of the disorganised atoms by electrons might supply the energy to force out the partially liberated helium or neon. In some recent experiments by Mr. R. W. Lawson, helium and neon were obtained by the passage of electricity through new apparatus, whereas tubes of the same material and pattern, after being in use for several months, were incapable of presenting any traces of these gases when subjected to precisely similar treatment.

The Forefront of Research

Here we must end. We have arrived at the forefront of the onward wave of scientific research, and the next few years will undoubtedly see a great revolution in our conception of matter and its transformations. For the first time, speculations as to the nature and even the origin of matter have become a legitimate subject for discussion and future verification.

Photo International Press Photo Co., New York

Floating Homes on a River in Siam

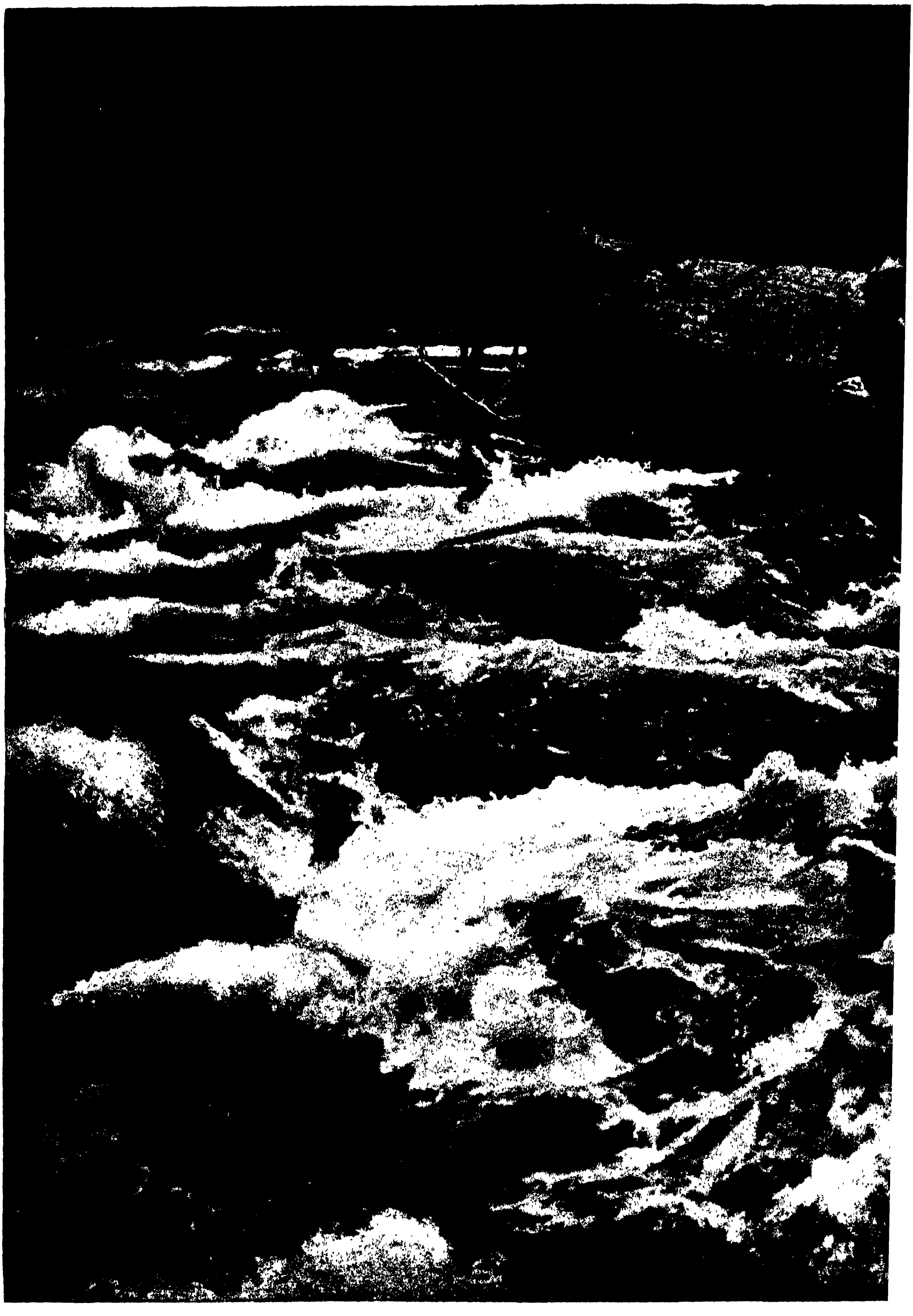
People Who Live in Boats

Concerning the Remarkable Folk of all Nations who Prefer to Spend their Lives upon the Waters

By N. F. WATSON

THE world possesses many people whose lives, like the bread of kindness, are thrown upon the waters. To find examples we need travel no farther than our own navigable rivers and canals, where families have their homes in canal boats, where children are born and grow to old age with no more taste for dwellings of bricks and mortar than a certain worthy old gipsy known to the present writer, who, forced at last by illness to quit his leaky caravan during winter, took shelter in a more conventional dwelling. But he could not rest, as others of us rest, in an ordinary house. He did not furnish; he put up no bedstead. He rigged up his little tent in one of the living-rooms, and there slept and fed himself into convalescence and greater love than ever for the wind on the heath and the blue sky over all.

From the dawn of navigation there must have been men who have spent the greater part of their lives in boats. We derive some notion of the habit from the fact that, according to Herodotus, Necho, King of Egypt in the seventh century B.C., led or sent his Phœnicians from the Red Sea round the entire coast line of Africa.



A HOME IN JEOPARDY—SHAN RIVER DWELLE

The dwelling-places of the Shans who follow the aquatic side of life are curious structures, rough shanties fou

Photo by Count Tanneguy d'Osmoy

NAVIGATING THE RAPIDS OF THE NAM-KHAM RIVER

upon elongated rafts, yet in these they descend with inimitable skill the wildest rapids and the rockiest passages

They were three years on their journey. They landed and planted corn, and waited to reap their harvest before continuing on their way, and eventually reached the Mediterranean, after a thrilling voyage. That is the minimum time, too, which certain men of our own day who live in ships (the five-and-twenty men of the Stefansson expedition who are lost in the Arctic ice in the little *Karluk*) will take to drift across the North Pole, as they are now expected to do. But their time may be twice as long, in which case the voyage will end a year too late to save their lives.

Three-year Voyages

The men who made our name and fame on the high seas practically lived in their boats, for boats they were. Sir Hugh Willoughby, founder of Newfoundland, was drowned in a ten-tonner, and the hardy fishermen who first reached the Newfoundland fisheries rowed with bleeding hands a great part of the way across the Atlantic, and lay at night under such protection as undecked boats could afford. The fight of the " one and the fifty-three," Sir Richard Grenville in the *Revenge* against a Spanish fleet, was fought by the English in a 100-tonner not wholly decked.

But the man with boat for home is not dead. We have in various parts of the world a marvellous assortment of these aquatic abodes. The newest thing in Eastern craft is as old at least as Eastern civilisation or communal life. The same type of vessel which Marco Polo saw when visiting China and India, over six centuries ago, crowds the Eastern rivers and dots the seaboard of those lands to this hour. Long before England was sovereign mistress of the seas the Orientals had their light, darting craft. What we are asked to accept as reliable records go to show that India had her fleets, in which her swarthy sons lived and moved and had their being, *seventy centuries* before that historic autumn day when Cæsar set out from conquered Gaul to drive his war galleons and transports, with their cavalry and infantry, up to the white walls of Dover. Except that they now have sails where before man-power was the motive force, Eastern craft have differed less through the ages than most of us would credit. The trade of China is many thousands of years old, and her rivers and harbours have always been there to navigate, and have been navigated. Certain types of Chinese are as much at home upon the water as upon the land; the boat is the home, the home is the boat. Railways are new and rates high, but the water highway from time immemorial was, and remains, cheap, the cost of material and labour for building not excessive, with the result that scores of thousands of boats, sampans, junks, craft of all sorts, throng the rivers and form the homes of a floating population of all ages.

In these vessels live the owner with his wife and children, eating and sleeping on board, as peaceful navigators should. Down stream they drift with the current; up stream they haul, helped by coolies. The " foreign devil " calls these junks clumsy, unhandsome craft, but there are junks and junks. There are those with rough sails of vegetable fibre; there are those which would pass for a rather bizarre type of houseboat proper; others which would not seem out of place as dahabeeyahs placidly floating on the bosom of old Nile. Some of them, though not built for the purpose, prove quite good sea-going boats, and some have reached America and Europe. Thus these queer boats have actually attained a reversal of the plan which Columbus set out to accomplish, when, seeking a westward way to far Cathay, he stumbled upon America and believed that he had actually achieved his goal.

The Unhandsome Junk

A little incident at home may be accepted as evidence of the sea-going qualities of these junks. When the Great Exhibition of 1851 was opened in London by Queen

Photo by permission of the Queensland Government

Carrying Water in Canvas Bags to a Pearling Boat

The pearl fishers of Australasian waters are, throughout the time of preparation for the harvesting of pearls, dependent solely for transport and shelter upon their fragile boats

Victoria, and the choir was singing the "Hallelujah Chorus," a Chinaman, gorgeously arrayed, suddenly emerged from the crowd and prostrated himself at the feet of the Queen. The latter, thinking that the stranger was some exalted personage of that far land—possibly the very Emperor come by stealth to see the wonders of the Western world, ordered that fitting place should be provided for His Celestial Highness. And in the procession round the building the Chinaman walked, between the Archbishop of Canterbury and the Duke of Wellington, smiling and bowing on all hands, to the great gratification of the Queen and the infinite content of the onlookers. But next day the murder was out. The supposed Emperor was one of the men that live in boats. He had sailed his junk across Pacific and Atlantic, and there she lay on exhibition in the Thames.

A Chinese "Emperor"

But the boat-dwellers are not restricted to China proper. Manchurian waters teem with them. The Liao river, the primary trade artery, has its seasonal crowdings just as great as the Chinese rivers. Thousands upon thousands of carts and wagons draw into Newchwang and other centres, bringing their wares to be stored at various depots during the winter until the ice breaks up. At that time the boats are either drawn up on land to become huts, or are moored at the water's edge. The moment the weather opens the river is alive with traffic, and the boat-dwellers are supreme. It is estimated that there are between 20,000 and 30,000 of these craft on the Liao, and allowing crews of from only three to four each, there must be close upon 100,000 men constantly living in these vessels, to say nothing of their women folk and children.

The inland waterways of Siam present just as animated an appearance at practically all periods of the year. The more interesting examples of boat life, however, are to be found farther from these vast hives of aquatic humanity, among the natives of the Pacific islands, in pearl-strewn Australasian waters, and, at the other end of the world, among the Eskimos. The pearl fishers of Australasian waters are, throughout the time of preparation for the harvesting of pearls, dependent solely for transport and shelter upon their fragile boats. The Pacific islander in his hand-made "proa" can rest like a gull upon the waves, and, according to high nautical authority, beat for speed the fastest sailing yacht or sailing ship afloat. The flying proa is credited with twenty knots an hour!

Japan supplies her quota to the water-haunting community. They are old at the work. Until her great awakening, Japan expected her coastal and island population to be, within limits, good watermen, as much at home on coast and river as upon the land. But there was a law prohibiting the making of craft too good. They had to be so constructed that they would capsize if they got out of sight of land; meaning, of course, that they must not be sea-going craft, which would enable the people to get away and carry Japanese secrets to the outer and despised world. And that lasted up to the middle life of men who lived to see the Japanese fleet send the Russian to the bottom.

The Shans are a strange Asiatic people, the beginnings of whose civilisation are lost in the mists of history. Although they may change with the inevitable forward thrust of civilisation and infiltration of Western ideas into their land, they still cling fervidly to their ancient institutions. Those of them who follow the aquatic side of life live in and navigate the strangest of craft upon their inland and coastal waters. Their dwelling-places upon the deeps are curious structures, rough shanties founded upon elongated rafts, yet in these they descend with inimitable skill the wildest rapids and the rockiest passages.

I.—On the Land: Natural

Wonders of Reptile Life

A Venomous Lizard—Ringhal's Cobra, a Reptile Marksman

By W. S. BERRIDGE, F.Z.S.

OF the many and varied members of the reptile kingdom, an unusual and somewhat morbid interest is attached to those that are possessed of poisonous properties. With the exception of one genus of lizard, all the poisonous reptiles are snakes.

Only one venomous reptile is indigenous to the British Isles—namely, the viper or adder. It can usually be distinguished by the dark zigzag pattern that decorates its body, but this, unfortunately, is sometimes very indistinct, and undue reliance should not be placed upon the feature as an unfailing means of identification.

The venom of snakes is a thick and almost colourless fluid, and in most cases very powerful in its action, retaining its poisonous properties for a great length of time, even in a dried state. Some thus preserved for over twenty-two years was found to have lost none of its power. Snake poison is inoperative unless it enters the blood of a victim; it can be swallowed without danger, the digestive juices rendering it innocuous.

Few snakes, if any, can vie with the cobras for their activity and deadly character. There are a number of various species, and all possess the power to erect the skin folds of their neck into the form of a hood. With the Indian cobra this hood is usually decorated upon the back with a spectacle-shaped mark, but sometimes it takes a more or less circular form. The Ringhal cobra is endowed with the peculiar gift of being able to spit out poison from its fangs for a distance of quite 6 feet. The reptile invariably aims at the eyes of an adversary, and should the direction be true, its poison will cause a temporary blindness—fortunately not attended with any permanent ill effects. Needless to say, its bite is fatal. At the London Zoological Gardens the keepers take special precautions against the behaviour of this snake and invariably wear motor goggles to protect their eyes whilst attending them.

Photo W. S. Berridge, F.Z.S.

Ringhal's Cobra

Mention must be made of the rattlesnake, which is unique in possessing a curious attachment at the end of its tail composed of a number of horn-like segments. When the snake is disturbed or annoyed it causes these to vibrate rapidly, thus giving rise to a loud rattling sound. The rattle, which in the young commences as a small button-like structure, increases in size as the reptile

The Iguana, a Giant Lizard, sometimes Five Feet Long

One of the best known species is the highly decorative tuberculated iguana Their predominant colour is green, harmonising with the trees among which they search for leaves and berries

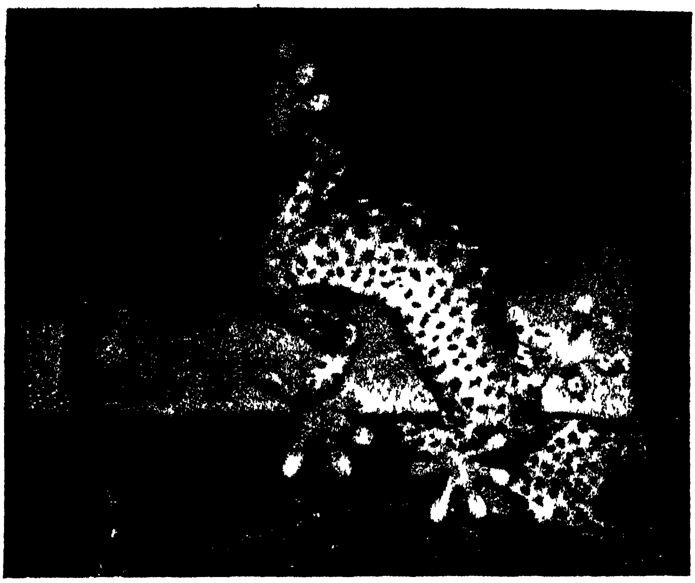


Photo W S Berridge, F Z S

The Gecko

It is characterised by small sucker-like discs on the end of its toes

attains maturity, until as many as twenty segments may be present.

It is a curious fact that the majority of venomous snakes are, in spite of their powers, of a sluggish rather than an aggressive nature, and, unless pressed by hunger, prefer to make their presence evident by hissing (or rattling, as the case may be), and thus avoid further action.

As a rule snakes are not very remarkable for beautiful coloration; certain species, however, prove an exception, and are endowed with quite a handsome exterior, especially after having shed their old skin. Russell's viper, a native of India, Ceylon, Siam, and Burma, is boldly marked with a series of dark chocolate-coloured rings, which stand out in strong relief against the general buff colour of the body. From this feature the reptile is also known as the chain viper. It is by no means a large species, only growing to a length of about 4 feet; nevertheless, next to the cobra, it is the most deadly snake in India.

Snake-bites are annually responsible for a large number of deaths. According to the Consular reports of India, we find that no less than 22,478 lives were lost there in the year 1910, and the figures reached the high total of 24,264 in 1911—figures that bring home to the most unimaginative person the terrible power these creatures possess, more especially when we consider that they are the records from only one country.

Of the single genus of poisonous lizard there are two species, the one being found in Western Mexico whilst the other inhabits New Mexico and Arizona.

Known as helodcrms or Gila monsters, these reptiles at once arrest attention on account of their beautiful colouring, the general tint of the body being salmon colour, upon which appears a bold design in black. The skin has the peculiar appearance of being composed of a number of globular balls placed one against the other. A bite from one of these lizards quickly overcomes small mammals and birds, and has even proved fatal to man. As a rule, however, its venom is not sufficiently powerful to kill human beings.

On glancing at the accompanying coloured plate it will be noticed that the heloderm possesses a thick and comparatively blunt-

Photo W S Berridge, F Z S

Spanish Scorpion

With poison sting raised in attitude of defence ended tail; this serves as a storehouse for the accumulation of fat, upon which the creature can sustain life in times of need.

Passing to the non-poisonous lizards, we find there are many types of exceptional interest. The monitors hold the distinction of being the largest of all, and occasionally attain to a length of almost 7 feet. Extremely active in their movements, and having the grip of a bulldog, these creatures prove formidable foes. When fighting, they make use of their long whip-like tails to good effect, and also play havoc with their sharp claws. The tongue of a monitor is very peculiar and suggests that of a snake, being deeply forked at the extremity. Their food is of a very varied nature, and consists of frogs, snakes, small mammals and birds, whilst eggs (especially those of the crocodile) are greatly esteemed.

Little inferior in size to the preceding are the iguanas, some of which grow to a length of between 4 and 5 feet. One of the best known species is the tuberculated iguana, a highly decorative creature possessing a row of upstanding spines along the back of the head and extending to the tail, while the throat is furthermore adorned with a large fringe-like appendage. They vary somewhat in colour, their dominant hue being green.

Iguanas are arboreal in habit, of a very active disposition, and feed principally upon leaves and berries. Their flesh is in much demand as a table delicacy and is said to taste like chicken; their eggs are also greatly appreciated.

Few lizards are more remarkable than the frilled lizard, a native of Australia. It is characterised by having a large outgrowth of skin sprouting from the back of the head and attached to the sides of the

Photo Doubleday, Page & Co

The Chuck-walla Inflating its Skin to the Utmost

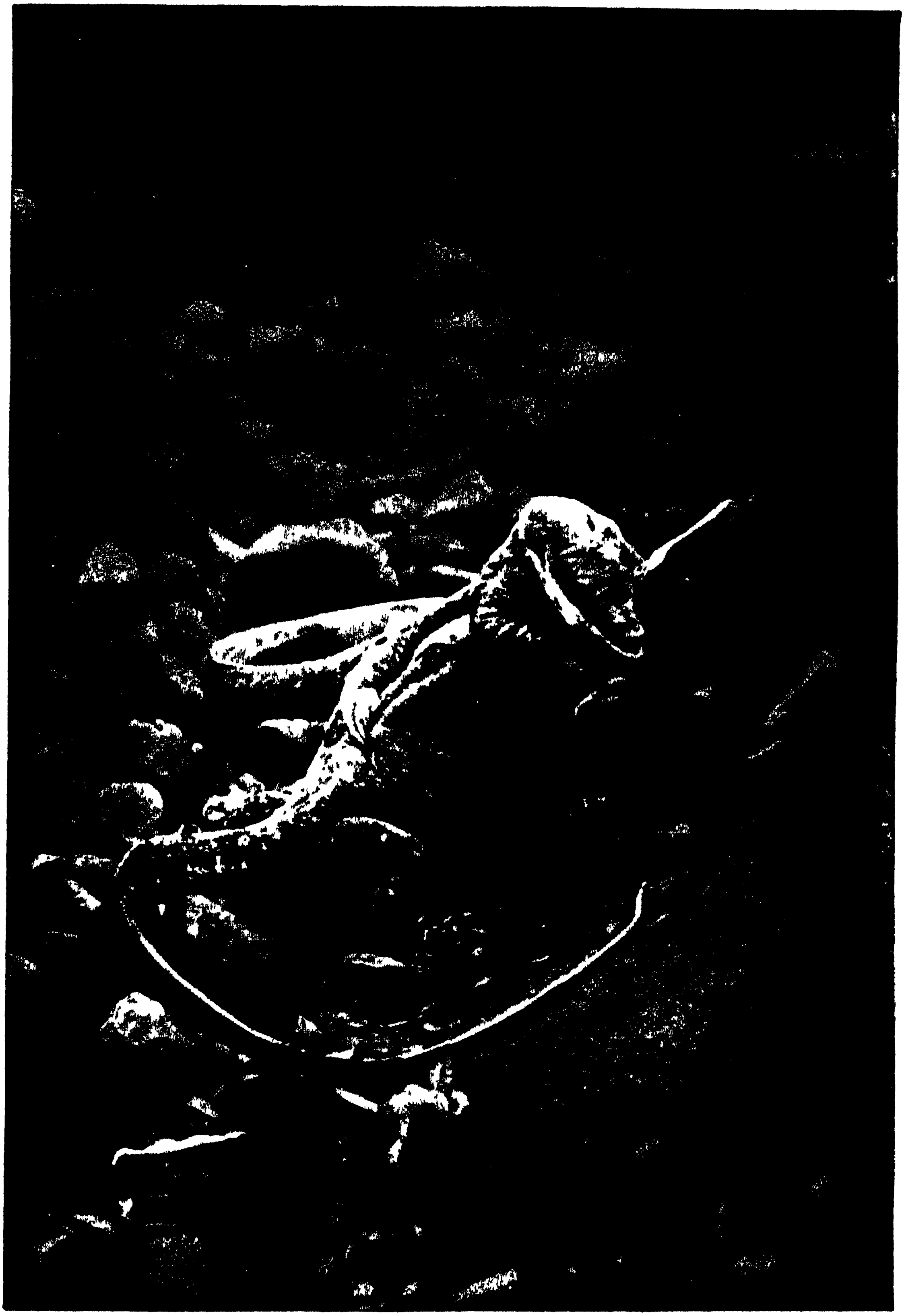


Photo M H François

Giant Australian Monitor Lizards

Sometimes attaining a length of 7 feet, the monitors have the grip of a bulldog, and also play havoc with their sharp claws. In the instance here illustrated a rifle shot concluded the struggles of both neck. Under normal conditions this is folded up and lies over the reptile's shoulders, but under stress of excitement or fear the lizard causes it to expand (much in the manner of opening an umbrella), and presents to view a large disc-like frill, almost completely encircling its head, and measuring as much as 10 inches across. The effect produced is usually sufficient to cause most creatures to pause and consider twice before attacking. The frilled lizard is extremely active, and when in a great hurry frequently runs upon its hind legs alone—the head, forelegs and body being raised off the ground—a feature which, although unusual, is common to a few other species of lizards.

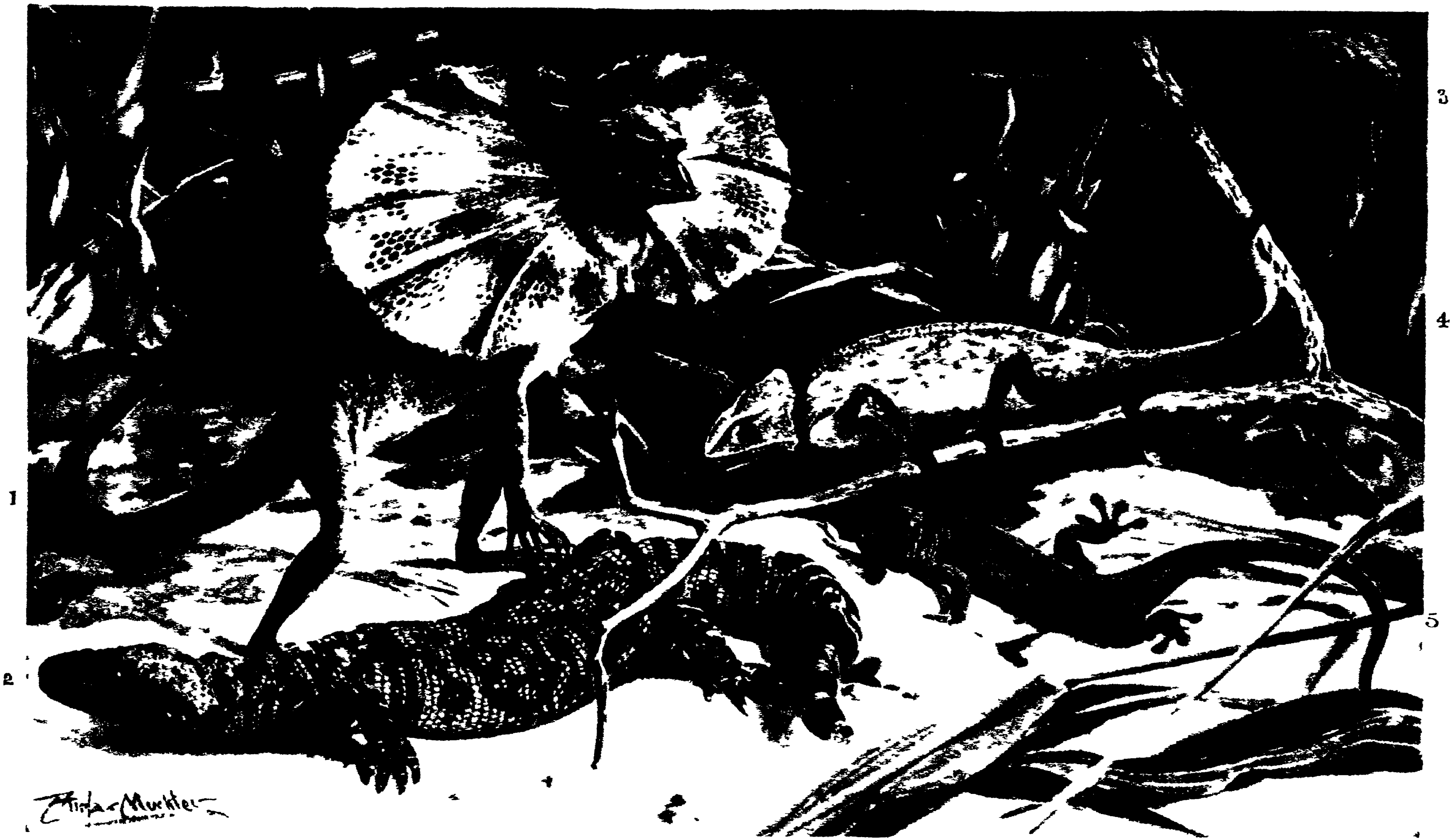
With the chameleons, possessed of marvellous colour-changing powers, we come to a class of reptile that is unique in many particulars. We find that the large and prominent eyes are covered by granular skin, pierced in the centre by a small hole to reveal the tiny pupil. Each one is capable of individual movement, and rotates so freely within its socket that it can be focused in almost any direction. The chameleon lives entirely upon insects, and when feeding, its long tongue is shot out with lightning-like rapidity, and (directly the club-shaped and sticky extremity touches its prey) as quickly withdrawn into the mouth with the insect adhering to it. The formation of the feet is very remarkable, for they are divided into two flap-like sections, opposable to one another when grasping. This peculiarity has given rise to the alternative name that these creatures receive of "four-handed lizards." The tail is long and prehensile, and when not in use is generally rolled up into a neat and compact coil. There are about fifty known species of chameleon, and it is of interest to note that whereas some are viviparous, others produce their young from eggs.

Of the smaller types of lizards, the geckos, with few exceptions, are characterised by the possession of small sucker-like discs upon the end of their toes. These enable them to walk up perpendicular and smooth surfaces, and to emulate the tactics of the familiar house-fly in its upside-down journey across a ceiling

Photo Lafayette Studio, Perth, W.A.

The Australian Spiny Lizard (*Moloch horridus*)

In spite of its truly formidable appearance, it is harmless



A Group of Lizards

1. Frilled Lizard (*Chlamydosaurus Kingi*)
2. Gila Monster (*Heloderma horridum*)
3. Tuberculated Iguana (*Iguana tuberculata*)
4. Chamæleon (*Chamæleo vulgaris*)
5. Green Gecko (*Phelsuma madagascariense*)

Curiosities of the Plant World

Robber Plants—"Rains of Sulphur and Blood"—Can Plants Remember?—Amazing Trees

By S. LEONARD BASTIN

Author of "Wonders of Plant Life," &c.

THERE is no more singular group of plants than that of the robber species, which, in their modes of life, resemble to a remarkable extent the human parasites who are such a nuisance to society.

Plant Thugs

There are a large number of plants which, though quite honest livers, in the sense that they get their own food, cannot be quite acquitted of depending unduly on their more sturdy brethren. Thus the honeysuckle, owing to its weakly stem, can only climb by seizing hold of some tree; it encircles the trunk and branches of its victim with an iron grip, and often the tree is strangled to death. In very much the same way even the innocent looking ivy will choke a tree with its strong, twining stems. In the tropical forests of South America the lianas are even more remarkable. These creepers grow out in the form of great strap-like stems, and often enough kill the trees over which they are scrambling.

After all, however, these climbing plants cannot be said to get their living from their neighbours. When we come to consider the genuine parasites we are faced with a very different state of affairs. Of these we may take the mistletoe as a very mild type. As is well known, this plant lives upon apple and other kinds of trees, sending its roots into the tissue of the host and drawing away the sap. This it does not do to a dangerous extent, and it is rarely that the tree suffers much from having a few mistletoe plants upon it. The possession of green leaves is a sign of honesty in the vegetable world, for plants so adorned are able to manufacture solid matter out of the gases of the atmosphere; so that although the foliage of the mistletoe is not very green, yet it is certainly doing something towards making a living for itself. Thus we must regard the mistletoe as a boarder who pays something, at any rate, towards his keep.

Robber Plants

The advanced plant parasites are much more abandoned criminals. Here we find a group wholly given over to robbery, and, indeed, in most cases these subjects are so depraved that they have quite lost the power of making a living on their own account. Some of these abandoned plants have a peculiarly mean mode of attack, in that they fasten themselves upon the roots of their hosts. Of these the toothwort is a singular example. This plant usually starts on the roots of alder or hazel bushes, to which it attaches itself by means of small suckers which draw away the life-giving sap from the tree. In favourable circumstances the plant grows very rapidly, and extends underground by creeping stems which resemble nothing so much as strings of teeth of an ivory whiteness. Finally, the plant sends up its flowers, which are of a pale lilac colour At no time does the toothwort bear any green leaves at all, and from beginning to end the whole of its existence depends upon stolen nutriment. One robber plant from Java, which also grows on the roots of trees, has the distinction of producing the largest flower in the world. This is the

Rafflesia Arnoldii, which, on the strength of the sap which it draws from its unfortunate host, contrives to develop a gigantic blossom that may measure 4 feet across.

The life history of the selfish dodder is a romance of a fascinating description. The seeds of the plant start very much in the usual way, save that instead of sending up any kind of leaves they develop a slender, thread-like growth. For a few days this shoot is sustained by the nutriment which was present in the seed, and also by means of the moisture which a temporary root secures from the soil. The delicate thread grows at a great pace, and all the time it is maintaining a constant movement from side to side, just as if it were searching for a victim. Sooner or later the fate of the dodder is decided. If there are no suitable plants within reach the little would-be parasite finally dies, although it has a marvellous power of vitality which may keep it going for a number of weeks. If it has the good fortune to come up against a suitable host, such, for instance, as a clover plant, the slender thread of the dodder at once encircles the stem of its victim.

A Shameless Bloodsucker

Very little happens for a while, save that the dodder absolutely separates itself from the soil, and henceforth it starts upon a life of the most shameless bloodsucking. At this stage the development of certain sucker-like processes by the dodder is the most important thing. These have the power of penetrating the tissue of the unhappy plant which is being attacked almost like a number of teeth. As soon as the first hold has been secured the robber plant grows amazingly. Its long, wire-like stems, now of a reddish colour, shoot out in all directions, and wherever these touch the stem of the host fresh batches of suckers are developed. In a few weeks the whole of the victim may be enveloped, and the robber plant often enough does its work so well that its miserable host is killed, having been literally bled to death. But the dodder does not mind very much, for its long stems have probably already seized hold of some fresh victim and its future well-being is thus assured. Late in the summer the dodder produces clusters of small white flowers. These, of course, set seed, the whole business being done at the expense of the host plant, and in this way provision is made for the following year.

"Rain of Sulphur"

In certain parts of the world superstitious peasants are often greatly alarmed during the summer months when they see the ground dusted with a yellow powder like sulphur. In some mysterious way this substance is held to have come straight from the infernal regions, and its presence is regarded as a sure portent of doom.

If the good people were a little more observant they would realise that there is nothing to give rise to alarm in the happening, for the so-called sulphur is simply the pollen of the fir trees. Huge tracts of land in Central Europe are covered with dense pine woods, and it is in these districts that the effect is most striking. In a normal season the firs produce a huge amount of yellow pollen the grains of which are floated by the breezes to the seed-bearing blossoms of the tree. Now and again comes a season when the quantity is simply prodigious, and in the neighbourhood of the forests the air is thick with the yellow dust. Finally, of course, the pollen settles on the ground, and there have been cases on record where the surface has been covered to the depth of nearly an inch. Sometimes the fall of pollen is associated with a heavy downpour of rain. Then great quantities of the grains are carried to the lower lands on the flooded streams. In this manner the country some distance away from the pine forests will be covered with long streaks of yellow powder. These have often caused a good deal of perplexity to enlightened people who could hardly

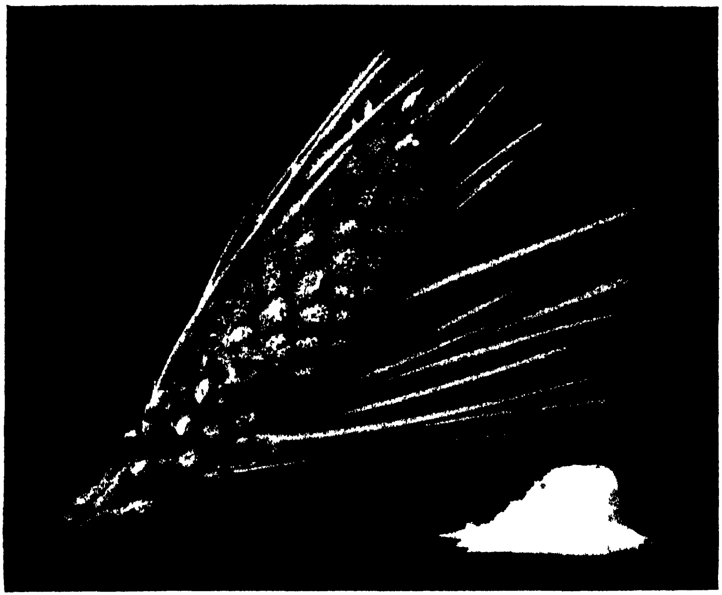


Photo S. L. Bastin

A Pine Flower and its Pollen

The pile of pollen shown is from a single flower

accept the idea of a fall of sulphur from the clouds.

Last winter it was reported that the peasants on the Swiss Austrian frontier in the Voralberg country had been alarmed by a heavy fall of red snow. The popular impression seems to be that this phenomenon is a sure sign of coming disaster. Most often it is considered that the incident is in some way connected with war, in which blood will be freely spilt. The botanist is bound to take a much more practical view of the matter, however, and to declare that the red snow is caused by a minute plant related to the seaweeds. Of course this plant is so small that the appearance of red snow is only secured when it is present in vast quantities.

The plant which forms the red snow is a singular organism with marvellous powers of reproduction. When the conditions are not very favourable for an active growth the cells of these minute plants float about in the atmosphere in a dry condition. After a fall of snow, when the circumstances are favourable, the little plants settle on the snow and start to increase with astonishing rapidity. As a rule the plant only puts in an appearance where the snow is of a more or less permanent nature. Sir John Ross, the

Photo S. L. Bastin

"Rain of Sulphur"

The so-called "rain of sulphur" consists simply of clouds of yellow pollen from the fir trees

Arctic explorer, has described the striking appearance produced by red snow in Baffin's Bay. Here he saw it covering vast areas many miles in extent. Moreover, the little plant was found to penetrate the snow to the depth of ten or twelve inches.

Many people who visit the Tropics for the first time are rather surprised to see trees bearing what appear to be candles. The strange sight is due to the candle tree, a species which is abundant in Central America, and is also to be seen frequently in botanical gardens in the warmer parts of the world. The so-called candles are really the fruit of this curious tree, and the illusion is made very complete by reason of the fact that the colour of the long processes is of a waxy yellow hue. Moreover, the fruit is largely borne on the trunk and the larger branches of the tree, so that the appearance is just as if a candle-maker had suspended a lot of his goods in order that they might dry. At the end of the fruit is a small tapering part which much resembles a thread, such as forms the wick of a candle.

Photo Agricultural Economist

The Candle Tree

When in fruit this Central American tree appears to be covered with candles

Another very singular plant from the tropical parts of South America is the cannon ball tree. This species, when it is in fruit, presents a most striking appearance. The whole tree is covered with large processes which are almost as big as footballs. Instead of being light and soft, however, the fruit of this tree is extremely hard on the outside, at any rate, and each specimen is a considerable weight. It is said to be rather dangerous to be in the vicinity of a cannon ball tree in full fruit, as one of these striking anybody on the head might cause fatal injuries. The natives of the district turn the fruits of the cannon ball tree to good account. Scooping out the somewhat softer interior, they fashion all kinds of vessels out of the hard shell.

One of the most interesting speculations which have recently been made in connection with plant life centres round the question of memory in the vegetable world. It is well known that certain plants, which expand their leaves by day to the fullest extent, show a very different bearing when darkness comes. This is notably so in the case of the French bean. Now these movements are, to an extent, traceable to the effect of the change in the degree of light on the living tissue of the leaf. In this connection Professor Darwin has carried out a very interesting experiment.

A bean plant which was in a healthy state was placed in an absolutely dark room. Now a very singular thing happened, for, although the plant was removed from the direct influence of the waning and waxing light, the movements of the leaves went on very much as before. Thus at about the hour of sunset the leaves drooped, whilst, when the morning light returned, the foliage was spread out again. This continued for several days with great regularity. Professor Darwin has pointed out that we may say that the cells of the plant *remembered* that which they had been in the habit of doing for so long. Thus the daily movements continued, even though the plant no longer came under the influence of the direct stimulus. It has been truly said that, even with highly intelligent man, it is only the "bridge of memory" that makes it possible for him to span the period of unconsciousness which comes every night with sleep.

There are few more amazing sights in the world than that of a tropical forest. The competition for room in which to grow is so keen that even the branches of the trees have been claimed by a special race of plants. These species must in no way be confused with the parasites which are such dreadful robbers, for the plants under consideration do no harm to their hosts. How, then, do they live at all? This was for a very long time a great puzzle, but there is no longer any doubt that they actually root in the air. Of course, we must remember that in these steamy jungles the atmosphere is simply saturated with moisture. This is especially so during the night, and it is at this time that the roots of the air plants absorb their water from the air.

One of the strangest of these air-rooting plants is the Spaniard's beard of Mexico. Near the famous palace citadel of Chapultepec the trees are densely covered with the long grey streamers of this singular growth. Really, in the strict sense of the word, it has no true roots at all, but is solely composed of long threads, the scales of which appear to absorb the needful amount of

Photo "Agricultural Economist"

The Cannon Ball Tree

The fruit of this tropical American tree curiously resembles cannon balls water. Closely allied, although very different in appearance, are certain plants (*Tillandsia*), which are abundant in the swamps of Florida. These are large handsome species, usually resting between the forks of some branches. Often enough the Tillandsias will find a small deposit of decayed leaves between the branches of the trees, into which they thrust their roots. They are, however, quite well able to live without any trace of soil at all. Many of these Tillandsias have a curious habit of collecting water in the cavities caused by the arrangement of their leaves. On occasion, the bodies of drowned insects are found in the hollows. It would seem that the plant is not above a little fly-catching, and that it is glad to make use of the mineral salts which exist in the bodies of its victims.

Air-rooting Plants

Of course, it is well known that a large number of orchids live on trees in the Tropics, and festoon the branches with the most gorgeous flowers. In the shady depths of the tropical jungle these plants send out huge quantities of roots which stretch out in all directions in the moisture-laden air. Another very singular air-rooting plant is the Stag's Horn fern of tropical Australia. This plant, in addition to the moisture which it secures from the air, luxuriates in the rotting leaves which may accumulate in the crevices of tree trunks. The development of great shields by the fern very much help it to capture leaves, etc., which may fall from the tree, and as these decay a fine-rooting medium is formed for the plant.

At first thought it seems absurd to suggest that anything which a plant could do would frighten animals. Yet there is little doubt that the seeds of certain species are capable of raising a good deal of alarm by their appearance. It is well known that many small animals and birds live upon seed to a great extent. Of course, in a large number of cases, where the actual seed is pleasant tasting, it is quite destroyed, and if this kind of thing were to go on without any check it would be very bad for the plant creation.

A clever method of guarding against the danger is that of producing seeds which bear a strong resemblance to beetles. In the Pacific Islands, for instance, there are a great many large and quite formidable beetles, some of which are almost as big as small birds, and few creatures would attack them. It is singular to note that some of the plants of these islands bear large seeds which, when lying on the ground, are really curiously like the beetles. A bird or a mouse passing by does not stop to investigate, as he is too much afraid to linger in the vicinity of what he conceives to be some monstrous insects. If he were not so readily deceived by appearances, how quick he would be to tear open the protecting shell of the seed and attack the kernel within. The common castor-oil plant also bears seeds which, on the surface at any rate, resemble beetles resting upon the ground. There is little doubt that these seeds often escape from attack by reason of their power to frighten animals away.

The life of the plant is one long battle against adverse conditions. On every side enemies threaten, but none of these is so menacing as the danger which arises from the weather. Scorching heat, bitter cold, and prolonged drought succeed one another; each of these is capable of wreaking the most fearful havoc on the unfortunate plant. Small wonder that a large number of interesting devices have been adopted by the plant to help it in its fight against the weather.

How Plants Fight the Weather

Certainly one of the most difficult weather conditions with which the plant has to contend is a drought. In temperate regions, where the conditions are relatively damp, the vegetation, as a whole, does not suffer greatly from lack of moisture. In the warmer parts of the world it is very

Photo L Gimpel

A Priceless Orchid (*Vanda Lowii*)

This rare flower is a native of Borneo. Even in its common forms 10,000 francs has been paid for a single specimen. The example here illustrated has 506 flowers and 215 leaves on 15 exceptionally supple stalks, of which one is 5 feet 8 inches long. It is the finest known, and was cultivated in Dr. Edmond Fournier's hothouse at Neuilly

Photo: S. L. Bastin

The Saxifrage—a Touring Plant

This plant contrives to survive and spread in arid places by sending out runners to find and take root in patches of earth

different. A Southern European fern has adopted a singular plan of keeping itself alive in very dry weather. The plant grows naturally on rocks, and as long as there is plenty of moisture available the foliage is fully expanded. After a week or ten days of dry weather, the leaves are closed together, so that the hairy underside of the frond is alone uppermost. In this way the plant is able to keep for itself any little dampness which it may have in its foliage. Even more singular is the Resurrection plant—really a kind of club moss from Mexico. This plant, which also grows in rock crevices, opens out into a beautiful green rosette in damp weather. At the coming of dry weather, which in Mexico may last for many weeks, the Resurrection plant draws its fronds tightly together so that it exactly resembles a dead plant. Perhaps more strange still, in the way in which it fights the dry season, is the Himalayan Arum, commonly known as the Monarch of the East. In its native locality there is a very wet spell followed by a long period of the utmost dryness. All through the moist time the arum grows vigorously, throwing up a large amount of foliage. During this time a great amount of nutriment is stored away in a huge bulb. There is so much energy available that the plant throws up a huge flower spike, and this it will do even when the soil is dust dry. Indeed, quite often no attempt to send roots into the soil is made.

In a general way, plants delight in the rays of the sun, but there are times when these may be too powerful. In Australia, the great Eucalpytus trees develop their leaves so that these hang edgeways to the light. Thus the forests of the island continent are almost shadeless. Another curious plant which dodges the sun is the Compass plant. This species is a native of the North American prairies, and, growing as it does in very exposed places, is much in danger of being scorched. To prevent its foliage being damaged by the sun, the Compass plant always grows with its leaves pointing due north and south. Thus the broad side of the plant is only exposed to the east and west, where there is little danger from direct sunlight.

Plants, of course, suffer very much from the cold. All sorts of plans have been adopted to keep the flowers and leaves from losing too much warmth. On cold days many of our common weeds, such as the clover and wood-sorrel, close their leaves together. The daisies and other kinds of flowers will not open their buds. A curious means of protecting the plant from cold is by clothing parts of it with a coating of hairs. One of the most interesting species in this respect is the Edelweiss. This plant, growing as it does on mountain heights, is, even in the summer time, often exposed to keen frost. As a protection, the whole plant, not only the foliage, but the flowers as well, is covered with a thick woolly substance. This covering will also play a helpful part in enabling the Edelweiss to conserve its moisture.

Another beautiful example of a well-protected plant is to be seen in the case of the Silver Tree of Table Mountain, S. Africa. Here the whole leaf is covered with a delicate grey silk, which protects the plant from the cold.

Units of Measurement

How Man's Methods of Measurement Serve as a Standard by which to Gauge his Civilisation

By W. HUTTON WILLIAMS, M.I.M.M., F.G.S.

BY no standard may the measure of man's progress be better gauged than by the gradual refinement of his methods in the art of measurement. The requirements of civilised communities to-day in this direction differ widely from those of even a few generations ago. We are not now considering the methods of the geometers and mathematical philosophers; the systems of reasoning which have gradually built up the greatest and purest of the sciences have stood in the full glare of the noonday light from the earliest times, and their accuracy has withstood the most jealous destructive criticism. We are confining ourselves to the necessities of traders, the general demand for standards by the people—units which shall be invariable, and which can be compared definitely with those of other nations.

The measurement standards of the whole of the nations of the world are, as would be expected, of the greatest antiquity. They are, in most cases, originally derived from the natural dimensions of portions of man's own anatomy such as the foot, hand, span, cubit, fathom, and orgyia; or they are measures of a man's or animal's physical strength and endurance, such as the pace, the league ($\frac{1}{10}$th of a day's journey) and the pound. Still other units are the dimensions or weights of familiar natural objects, such as the barleycorn and grain.

The foot, cubit and fathom are in use as standards to-day, not only by the most enlightened of Western nations, and the highly civilised but uneducated nations of India and China, but also by the savages of the interior of Africa and Borneo.

The native of Korea will describe the depth of a hole or height of a tree as so many men, and the British collier will measure a piece of timber in terms of the shovel, forearm, and span, or of the man's height, fist, and finger. The adoption of such units was a fundamental comparative conception; their use marks a stage in the development of every infant born into the world to-day.

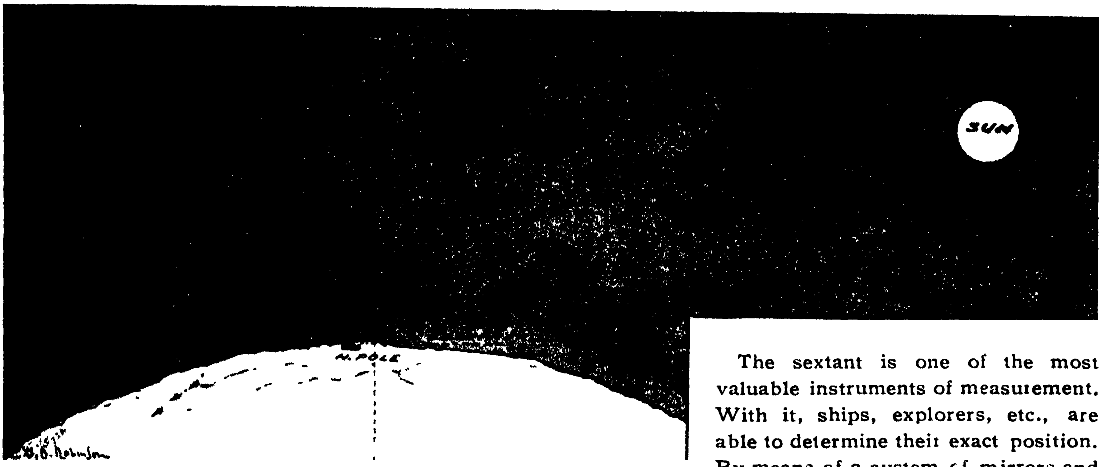
Of these units the foot is perhaps the most interesting. On comparing ancient units of length with our own standard, and taking the latter as unity, we find that the Babylonian foot was 1·14, the Hebrew 1·2, the old Arabian 1·10, the Greek 1·01, and the Roman 0·97. The Chinese foot is 1·05 of the English standard.

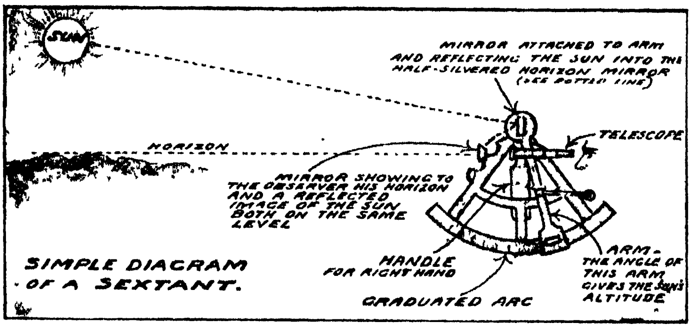
The equivalent of this unit is in use by every European nation to-day.

Another measure of world-wide use is the pound, which is a definite fraction of the load which can be transported by a man, or beast of burden such as a horse or bull.

The Attic mina was equal to 1·05 troy lb., and the Attic medical mina was within $\frac{8}{1000}$th of the lb. avoirdupois. The talent or 60 minae was ½ cwt. The old Greek mina was nearly 15 oz., while the Ptolemaic equivalent of Cleopatra was over 20 oz. The Roman 12-oz. lb., or 84 denarii, contained 5,246 English grains, against the 5,670 of the lb. troy. The Chinese pound contains 5,802 grains. The pound of Aleppo and Damascus would seem to present an anomaly at first sight, with their equivalents of 30,985 and 25,613 English grains. The former approximates to 5 and the latter to 4 lb. troy. To those who have seen the relationship which the load of the camel bears to that of the horse, this fact will be very suggestive, however.

To the French Revolutionary Government belongs the honour of the introduction of an original standard derived from an object of definite magnitude outside the human person. The "measure," or "metre," was defined as being $\frac{1}{10,000,000}$th of the length of the arc from the Equator to the Pole, on the meridian of Paris. Unfortunately, later determinations of the value of the quadrant have shown the original determination to




SUN
MIRROR ATTACHED TO ARM AND REFLECTING THE SUN INTO THE HALF-SILVERED HORIZON MIRROR (SEE DOTTED LINE)
TELESCOPE
HORIZON
MIRROR SHOWING TO THE OBSERVER HIS HORIZON AND A REFLECTED IMAGE OF THE SUN BOTH ON THE SAME LEVEL
SIMPLE DIAGRAM OF A SEXTANT.
HANDLE FOR RIGHT HAND
GRADUATED ARC
ARM - THE ANGLE OF THIS ARM GIVES THE SUN'S ALTITUDE

The sextant is one of the most valuable instruments of measurement. With it, ships, explorers, etc., are able to determine their exact position. By means of a system of mirrors and a divided arc, it is used to determine the altitude of a heavenly body; that is, the angular height above the horizon. A sextant has two mirrors, one of which is fixed to a movable index. The principle of the sextant depends on a theorem in optics that if an object be seen by repeated reflection from two mirrors, which are perpendicular to the same plane, the angular distance of the object from its image is double the inclination of the mirrors

Drawn by Frederic de Haenen.

Captain Amundsen Locating the South Pole

To find the angle between two stars (or the altitude of the sun above the earth's horizon), the instrument is held up so that one star is seen directly through the telescope and the unsilvered portion of the mirror. The index arm is then moved so that the image of the other star is nearly coincident with the first. The reading on the arc at the point to which the arm is moved gives the angle required. Thus the sextant fixes the observer's position be inaccurate, and also that it is changing (the latest estimate of mean quadrant is 10,002,100 metres). The magnificent original definition has consequently degenerated to: "The distance, at the melting point of ice, between the centres of two lines engraved upon the polished, 'neutral web,' surface of a platinum-iridium bar of X-shaped section, called the International Prototype Metre."

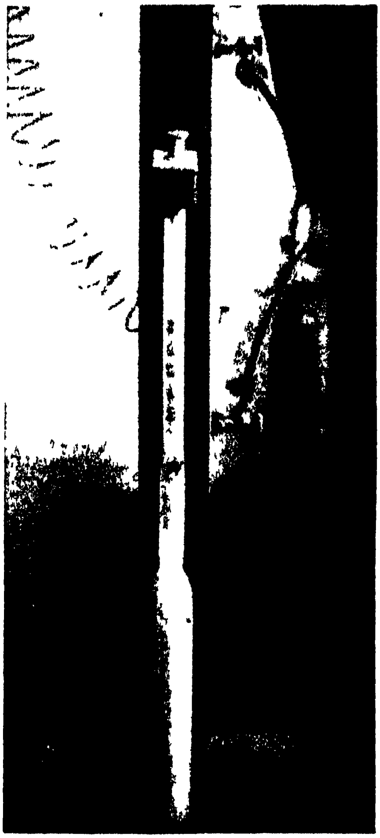


Photo. Clarke and Hyde

Mercurial Thermometer

With platinum contacts for use in the electrical control of temperature

The Metric standards of length and mass are kept at the International Bureau of Weights and Measures, Sèvres. The Bureau is maintained jointly by the principal civilised governments, as members of the Metric Convention.

Between the years 1736 and 1743 the Royal Society made some very accurate comparisons of English, French, and old Roman measurements, and George Graham (a watchmaker) determined the length of a pendulum which would vibrate single seconds at London to be 39·13 in. Following this, several committees were appointed to report to the House of Commons; nothing, however, seems to have been recorded before the report of a committee appointed in 1814, nineteen years after the French had legalised their standard. It was then reported that the length of a pendulum vibrating seconds had been ascertained; and Wollaston's suggestion that the gallon should be defined as the measure of ten pounds of pure water was first put forward.

In the year 1816, as the result of a humble petition from the House to the Prince Regent, the Astronomer-Royal was directed to perform the necessary operations for the comparison of the English "yard" with the "metre." The Astronomer-Royal prayed for assistance in the matter, and the Royal Society was then requested to appoint a committee to co-operate with him.

This committee, in their second report, stated that they had found the length of a pendulum vibrating seconds of mean solar time, in London, at sea-level, in a vacuum, to be 39·13929 in., and the length of the metre to be 39·37079 in.; both measured by the same English standard yard of 36 in., the standard being at a temperature of 62 degrees Fahrenheit. The gallon was defined as the measure of 10 lb. of pure water. The committee, after due deliberation, did not find themselves able to recommend any changes in the British standards of length and mass.

The present British Imperial standards—"yard," "pound" and "gallon"—as defined by the Weights and Measures Act, 1878, are—"the yard is the distance, at 62° F., between the central transverse lines in two gold plugs, in the bronze bar, called the Imperial Standard Yard; when supported on bronze-rollers in such a manner as best to avoid flexure of the bar."

The lines in the plugs are situate at the bottoms of two holes bored in the bar, so as to be in the median plane. The bar itself is 38 in. long and 1 in. square, and its composition is thirty-two parts copper, five parts tin, and two parts zinc. Copper alloys are now known to be unsuitable, and in 1902 a platinum-iridium X-shaped copy was made. The bar, with its supporting rollers is placed within a trough in order that it may be immersed in a bath to secure even temperature.

"The pound is the weight *in vacuo* of a platinum cylinder called the Imperial Standard Pound."

"The gallon contains 10 lb. weight of distilled water, weighed in air, against brass weights, when the barometer reads 30 in., and both water and air are at a temperature of 62° F."

The object of the words "against . . . weights" is to make the definition independent of the force of gravity, which it would not be if, for instance, a spring balance or other like weighing method were used. The barometer and thermometer secure standard density for the air and water. The photo on p. 914 shows the giant mercurial thermometer with platinum contacts used to control the temperature of the comparator chamber electrically and keep it at 62° F. The chamber is fitted with double doors and double windows. If the temperature falls below 62° F., radiator lamps are turned on automatically by the thermometer, the turning on being effected through relays. If the temperature rises above 62° F., a radiator which is normally on is turned off. Compensation is thus made automatically for changes of temperature. Unfortunately, no mention is made in the Act of the density of the brass of which the weights are made, or of the humidity of the air. Brass is an alloy of copper and zinc, and its density is variable. The amount of water vapour in the air affects its density, and therefore affects the buoyancy of the gallon of water and brass weights in an unequal degree.

The British Imperial Standards of length and mass are preserved at the Board of Trade (Standards Office), Old Palace Yard.

Photo Clarke and Hyde

Weighing a Pound with the Reflector Balance

The oscillations of the balance are transmitted by means of a combination of mirror and prism, and are observed through a telescope placed at a distance from the balance. The addition of $\frac{1}{10,000}$th part of a grain to one of the weights would be detected

II.—In the Underworld: Natural

The Sweden Valley Ice Mine

Forming Ice at Boiling Point—Summer-born Ice that Melts in Winter

By E. A. BRYANT

Author of "The New Self-Help"

BEWARE of frost-bite when, on a scorching summer's day, your car is running fast. Through the popping and misfiring of your engine, perhaps, you get down, raise the bonnet, and look for a broken or "shorting" ignition wire, or, it may be, a sooty sparking-plug. An astonishing picture meets your eye. The cylinder tops are unendurably hot, the fluid in the water-jackets is almost at boiling point, but there is ice in process of formation upon the pipe which conducts the vapourised petrol into the cylinders!

Frost-bite from Heat

Part of the engine is almost red-hot, the other covered with rime frost. Let it run while you keep your hand upon the induction pipe, and you will experience a frost-bite as effective as anything of the kind in Antarctica, where the temperature never rises quite clear of freezing-point. It is surprising, of course, but then, with a little patience, you can get frost-bite by thrusting your hand into a burning fiery furnace. This is no play upon words, nor hint of wizardry, but scientific fact.

The frost that you find under the bonnet of a car which has been running at 50 miles an hour is the external and visible product of evaporation. In vapourising, liquid absorbs a great degree of heat, and so rapidly lowers the temperature of the fluid remaining. Now in a fast-running car, petrol, passing rapidly from the carburettor to the mixing-chamber, and thence to the cylinders, becomes converted into pure gas. The rapidity and continuity of the evaporation absorbs so much heat that the induction pipe becomes a sort of refrigerator, and the warm air from the engine which impinges upon the induction pipe, is cooled, condensed and converted into frost. The faster your car runs the more certain are you to find ice about the induction pipe. The principle is well understood and turned to profit.

Ice Made in the Sun

On a blazing hot afternoon you can convert a vessel of ice-water into ice in the sun. As we all know, to keep water cool for drinking purposes in the heat, we store it in vessels of porous earthenware. The liquid percolates through the pores of the vessel in minute dew-drops, as it were, and slowly evaporates. In the evaporation it withdraws the heat from the water remaining in the vessel, which is always delightfully cool and drinkable. Now, to gain summer ice, we put a shallow vessel of water inside the receiver of an air-pump, in which also is placed a dish of strong sulphuric acid. When the air is withdrawn by the air-pump, the water evaporates readily, but the vapour given off is immediately absorbed by the acid. There being practically no air present in the vessel, the water continues to evaporate and to withdraw from the remainder the latent heat that it contains. Evaporation of the water, and absorption of the vapour by the acid thus continuing, the water left becomes so intensely cold that it freezes before one's eyes, though the sun overhead may be torrid in intensity.

Next, we carry the experiment further, and make a kettle of water provide us with ice made at boiling point. Here a second principle is involved—that of atmospheric pressure. At sea-level, water boils at 212° F., but at a lower temperature for a greater height. The weight of the atmosphere decreases, of course, the higher we ascend, and a point is reached at which water boils at so low a temperature that it will not cook certain foods. On the top of Mount Everest, for example, roughly 30,000 feet, the boiling point of water would be little over 150° F. We can obtain "mountain" conditions by applying an air-pump to a closed vessel, within which water is heated. With the air exhausted, the water boils at a low temperature. With a continuance of the pumping, and the exterior of the vessel sufficiently cooled, the water will continue violently to boil, while the steam congeals upon the sides of the vessel, until the whole becomes frozen into a snowy mass of ice. Faraday improved upon this by freezing mercury in a miniature furnace. He placed it in a small capsule in a white-hot vessel, accompanied by small quantities of solid carbonic acid and a preparation of ether. The heat caused the mercury to rise in a jet. The outer part of the jet evaporated so swiftly that the inner part turned to ice in the heart of the miniature furnace.

Drawn by Arthur Twidle

In the Sweden Valley Ice Mine

Miners, prospecting for silver, found subterranean ice, which, scientists declare, is actually formed in spring and summer and melts with the approach of winter

For these freakish phenomena ice obtains some compensation at the opposite end of the thermometer, for fresh water, kept perfectly still, will remain absolutely fluid when 10° F. below freezing point. The least shake or the dropping into it of a solid, will, however, cause an instant rise of 10°—and ice! Thus, Nature provides the novelist with a ready-made "situation." His escape cut off by still waters which are below freezing point, the hero casts a stone into the pool, turns the water to ice, walks over dry-shod, and so confounds the enemy.

Sweden Valley Ice Mine

Nature does not leave all her tricks with ice to the scientist. She makes solid rivers of it, in the form of glaciers, flow like water. But an even stranger phenomenon has just been solved in America, where summer ice-caverns have at last been investigated and explained. Europe has her ice caverns. That at Dobsina, in Hungary, is estimated to contain 6,000,000 cubic feet of ice, distributed over an area of 10,000 square yards. But the American ice-caves or ice-mines, as they are called, are, though less famous, more interesting. For they build up their ice in the heat of summer, and lose it in the winter!

Summer-formed Ice

The mines exist in Sweden Valley, near Coudersport, Pennsylvania, and are two in number, albeit others may yet be found. The story of their discovery is strange. Miners, prospecting for silver, found subterranean ice. In the shafts that were sunk in spring, ice began to form as the summer advanced, and grew thicker and thicker, until the end of July, when it began slowly to decrease. The phenomenon was repeated the following year, and every summer for several successive years. Scientists visited the scene, and after examination, declared that the ice was the unabsorbed product of winter. But the story of the men on the spot has been confirmed. Mr. Marlin Andrews, of Leigh University, South Bethlehem, Pennsylvania, has made careful observations, confirmed the story of the local residents, and printed his experiences in the American "Popular Science Monthly." Other men visited the mines only in summer; he carried out his investigations over an extended period, beginning in the spring before the ice had formed, and carrying them on until the deposit had reached maximum and begun to thaw. The explanation is striking and unusual.

The sides of the mines are composed of shale, which communicates by innumerable crevices and channels with rock composing the upper strata of the hill, at whose foot the mines are situated. The channels in the rock lead into the open air at various high-lying upper reaches of the hill. Air, entering by way of these rocky channels during winter, becomes rapidly chilled, and sinking, gradually finds its way down, by winding ways through the heart of the hill, where it must attain a temperature considerably below freezing point. The rocks underlying the mines, therefore, in Mr. Andrews' explanation, become "stored with cold." When the warmer air of spring arrives, the intensely cold air below rises and finds its way out through innumerable interstices in the shale. It issues with force sufficient, he finds, to extinguish a small taper. The hotter the day, the greater the outrush of air. The outpouring of cold air so thoroughly chills the interior of the mine as to cause the latter gradually to form ice. The process continues from week to week, until the end of July, when the maximum amount of ice is formed. Then, the store of "cold" in air and rocks being exhausted, the ice begins slowly to melt, and finally disappears at about the end of September, to re-form when the warm weather of the following spring arrives.

Where the Liquid comes from

The liquid from which the ice is formed is provided by a gradual percolation of moisture through the sides of the low-lying mines, in the same manner as the moisture issues from banks lining a country road, carved below the level of flanking fields, from which water is draining. Mr. Andrews appears not to have taken into account the possibility of evaporation playing a part in his ice mines. He tells us that on certain days the air can be seen issuing in the form of mist. As it rises cold and chilled from the lower strata, it must be heavily charged with moisture. The latter must naturally evaporate within the mine, and this might suffice, at least, to help the freezing process.

III.—On the Sea: Artificial

The Wonders of "Wireless"

Concerning the Life-saving Ethergrams which Call Help to Distressed Ships at Sea

By HORACE C. DAVIS

POSSIBLY no invention has, in so short an existence, saved so many valuable lives, or so many thousands of pounds' worth of property as wireless telegraphy. The method of sending signs through hundreds of miles of air, which, thanks to the genius of Marconi, has been in active existence for so few years, must be counted one of the modern wonders of the world.

The new century was but two years old when young Guglielmo Marconi achieved success by sending his first trans-oceanic message. Five years later he had so far perfected his apparatus that the new invention was established on a business basis, and in 1909 the State acquired his shore stations. The young Italian speedily became literally burdened with the honours showered upon him by all the nations of the civilised world, and to-day this modern wizard controls vast business concerns which have without a doubt made him a millionaire, while, more wonderful still, he has yet to see his fortieth birthday.

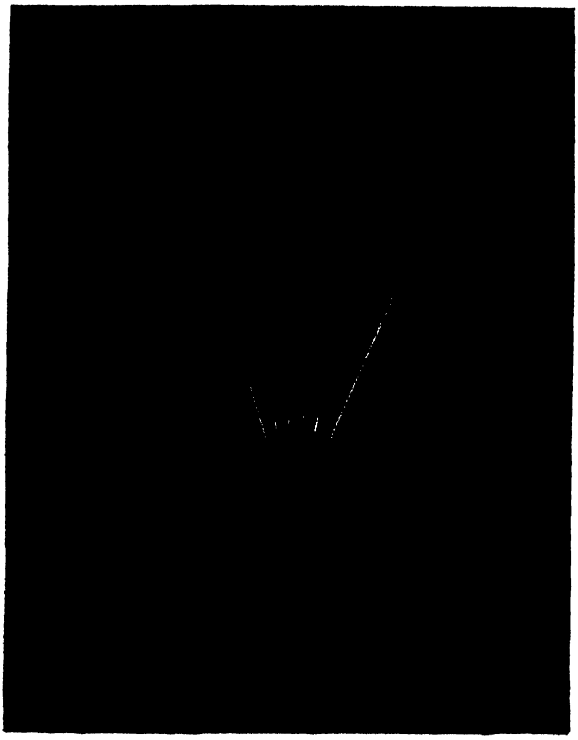
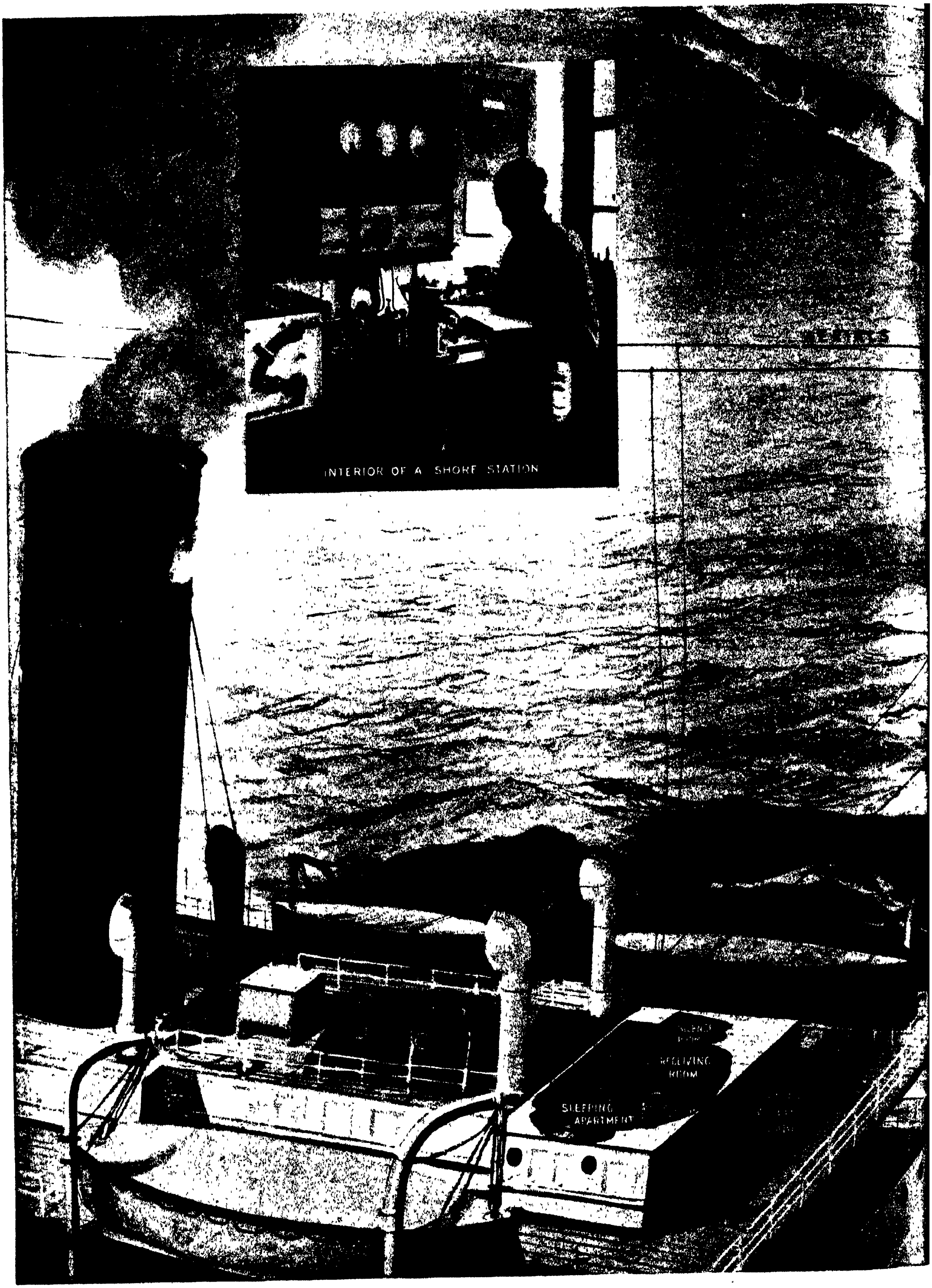


Photo J Gimpel

Telling the World Greenwich Time by Wireless

This photo was taken from the second platform of the Eiffel Tower, Paris (looking up), at the moment when midnight was being announced. The ultra-violet radiations appear luminous on the photographic plate

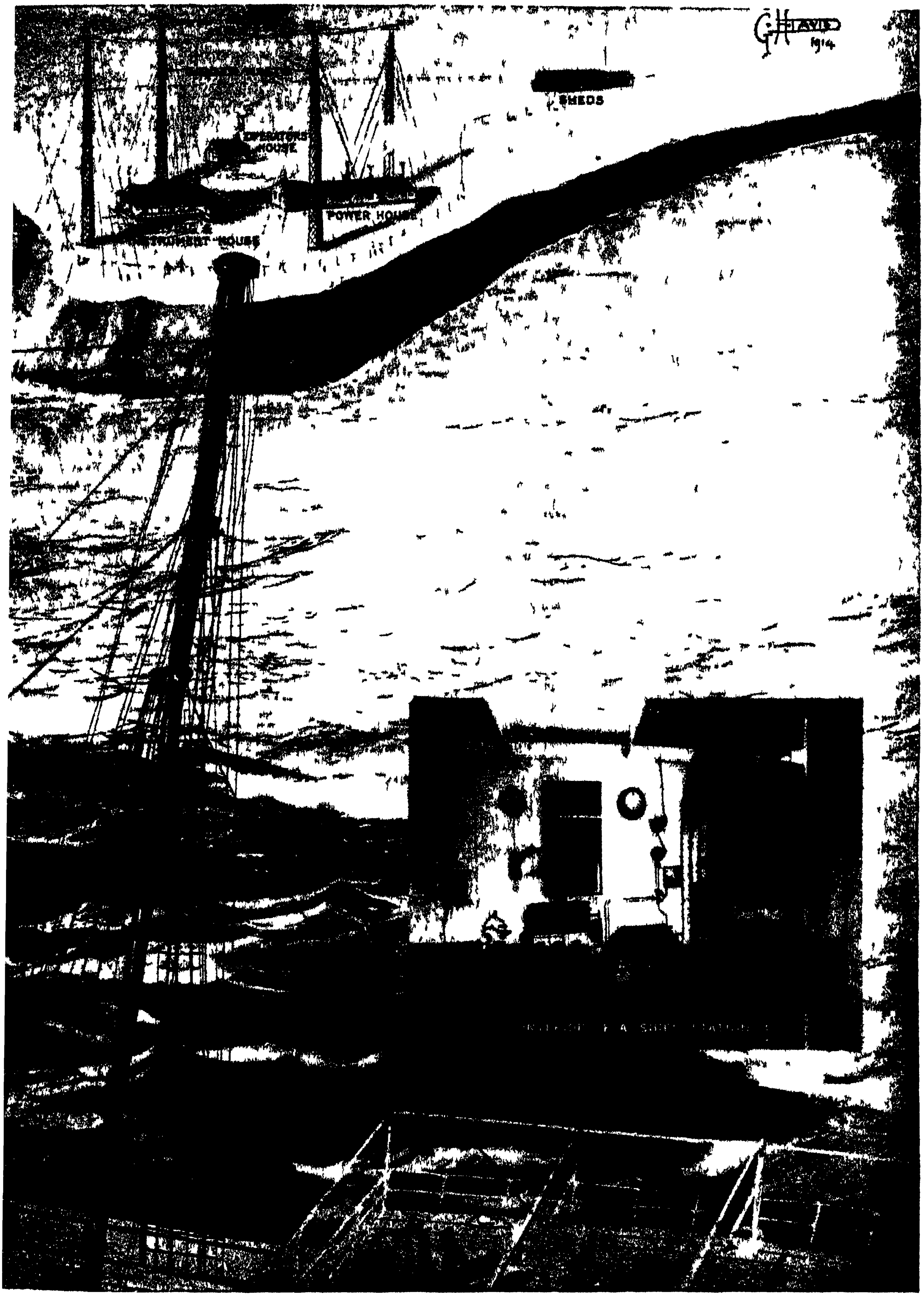
In the United Kingdom great wireless stations have been established in all parts of the country, and to visit any one of them is an education in itself. On a high cliff overlooking the wild coast scenery of Western Cornwall, is established the great Poldhu station, which has been described as one of the engineering marvels of the world. High above the barren rocks are the "masts," each 275 feet tall, and each strongly braced to withstand the ninety to a hundred-miles-an-hour gales that ever and anon shriek through their sustaining cables, each of which, to have the required strength, had fifteen tons of bolts, and 4,000 feet of steel cable used in its construction. In the power-house is a 200 horse-power engine, driving the dynamo to supply the necessary electrical power. The station contains the transmitters which can send the Hertzian waves throbbing their messages over thousands of miles of sea and land. Each time the operator taps his transmitting key the spark in the



HOW "WIRELESS" KEEPS UP COMMUNICATION

(Drawn by G. H. Davis. Photos by courtesy

In the power house of the shore station an engine of perhaps 200 horse-power drives the dynamo to supply the message is caught by the aerials stretching from masthead to masthead of the receiving



NSTANTLY BETWEEN SHIP AND SHORE

rconi's Wireless Telegraph Co, Ltd)

rical power necessary to send the Hertzian waves throbbing their messages over thousands of miles of sea. The , and transmitted through vertical wires to the instrument in the Marconi house silence room—rendered sound-proof by a stout packing of felt inside insulated iron casing—goes off with a volume of sound, from a voltage that runs into millions, and sends the invisible message on its way.

The Operator

On the upper deck of the receiving ship, steaming far at sea, is found the operator, ready to receive the story the land has to tell. High above his head, stretching from masthead to masthead, are the aerials. Here the message is caught, and transmitted through vertical wires to the instrument in the Marconi house, and there the dot and dash alphabet of the Morse code cracks in sharp and long sounds into the receivers strapped to the man's head. He places the message in writing as he is getting it, and then, in turn, may depress his lever, start his motors, and send a return message crackling shoreward.

Though it is impossible for an apparatus to be installed in a liner equalling the power of the great stations at Clifden, on the coast of Ireland, with its 3,000-mile range, or like those at Poldhu and Humberstone, nevertheless the equipment of the leviathan North Atlantic liners is powerful enough to keep them always in touch with land. When they can no longer send their messages back to Ireland they are able to communicate with Glace Bay, Newfoundland, on the opposite side of the Atlantic.

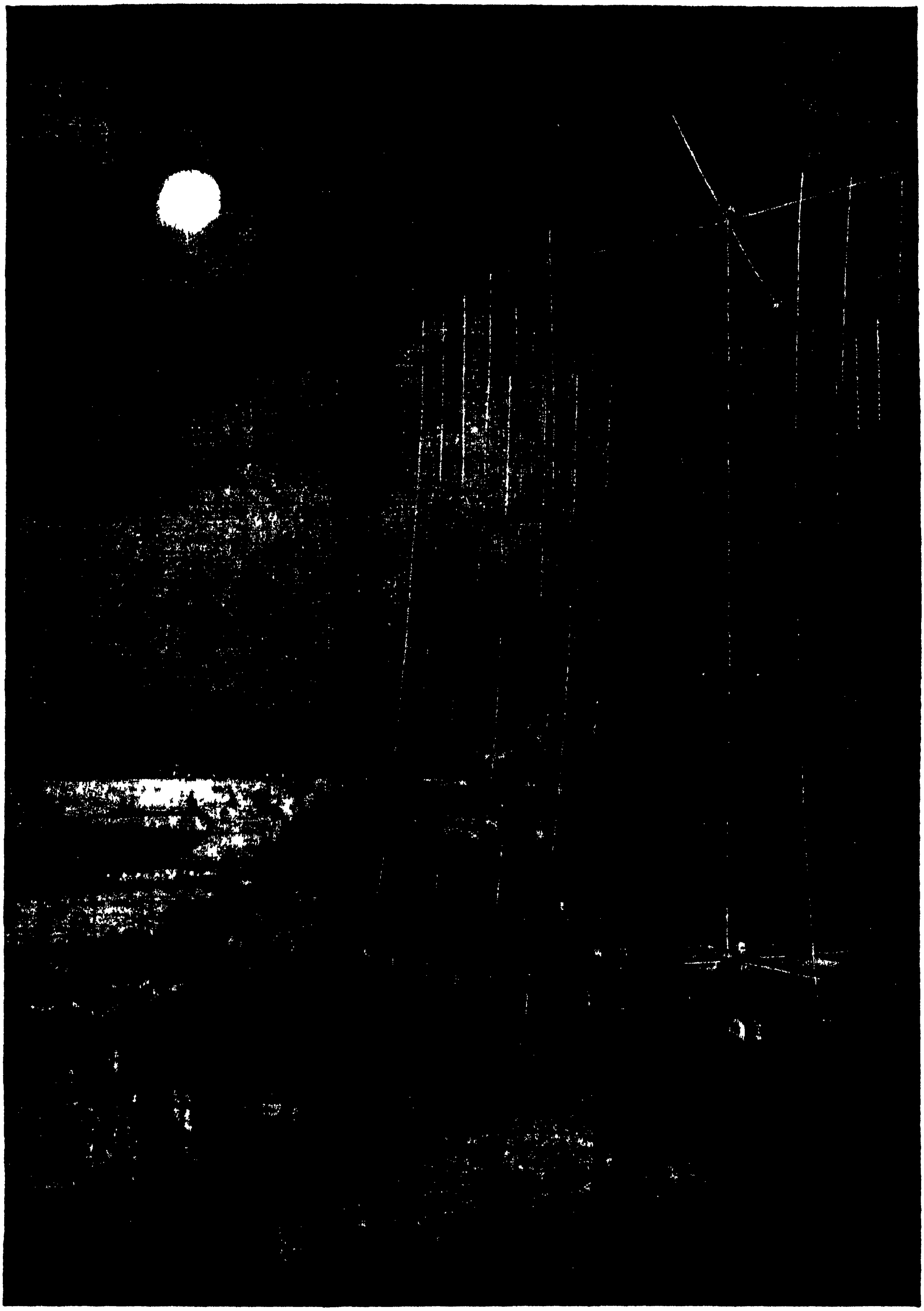
Naturally the first cost of these large "wireless" stations is very heavy, and such places as Clifden and Poldhu have very expensive equipment, costing anything between £180,000 and £200,000. The great platinum-coated balls, used in the earlier days of wireless telegraphy, were a very expensive item, the platinum costing about eighty-five shillings an ounce. To send a Marconigram to any large fast liner twenty-eight hours after she has sailed, costs as much as 10½d. per word, the charge increasing as the vessel gets farther and farther to sea.

As a result of the *Titanic* disaster every passenger ship must carry "wireless," which is admittedly as necessary an item in its equipment as the stowage of lifeboats capable of taking off all on board. Furthermore, there must be two operators, so that there is always someone on duty to pick up any messages that may come his way. For this work a new occupation has sprung up for young men, who are thoroughly trained before they are allowed to go to sea, and who receive wages varying from 15s. to £3 per week, with everything found. In the Navy a new rating had to be formed, and, though the budding naval operator must enter in the usual way, he eventually receives increased pay, which commences at 3s. 6d. per week on entry as a raw lad, up to 30s. per week when he gains the rank of petty officer.

In the liners of the merchant service the apparatus usually employed is a five-kilowatt set, which is equal to about 7 horse-power, and this will carry 500 to 600 miles normal range, and 1,000 miles after darkness, at which time the "wireless" waves are always at the limit of their power. When sent at such a time the message leaps away into the black, gusty void around the swaying aerials at the speed of 186,000 miles a second.

Wireless Telephony

To-day other systems have been introduced, and, though the Marconi apparatus is fitted to the major portion of the shipping of the world, it must not be understood that they have it all their own way. But Marconi has not been standing still, and he, and other active brains have been for years conducting experiments towards actually sending the human voice by means of these invisible electric waves. It was not until the early months of 1914 had passed that the world began to understand that at last the voice of man had been successfully transmitted in this way,



The Wireless Station at Boulogne-sur-Mer Glowing with Electric Energy at Night

(*Drawn by Harold Oakley*)

A vertical wire, A, from the roof aerial, enters the building at B through a vertical tunnel insulator. C, D, E and F are each harps of six wires suspended from the cable connecting the tops of the four towers, and joined up by a single conductor leading into the station

and the wireless telephone, with its boundless possibilities, had actually become an established fact. Signor Marconi conducted his experiments from an Italian warship, and though the work was carried out by daylight, when wireless is less efficient than it is at night, clear communication was received from the Rome station 300 miles away, from Venice, about 600 miles, and from Clifden, on the Galway coast, more than 1,700 miles distant. On the next day two battleships, steaming at a distance of 25 miles apart, were able to talk to each other in clear Italian.

In another direction, a wireless operator on the liner *Northland*, named Irving Vermilya, has invented a similar apparatus with which he can talk for 25 miles, and his wife, in their home at Mount Vernon, California, has received voice messages from her husband on the installation he fitted up at their house, without any alteration to the receiving instrument.

A Thing of the Past

The wonders of the wireless telephone open up a fresh field for the wireless system, and should the telephone without wires become an assured success (as it undoubtedly will), then it is possible that the telephone systems of the world, with their millions of miles of wires, will become a thing of the past.

In addition to the above scientific facts and costs, there is another side of this invention which is filled with romance, comedy, and a good deal of tragedy. First came the saving of hundreds of lives from the stricken liner *Republic*, which dispatched her "C.Q.D." messages for help in all directions, and brought every liner in her vicinity hurrying to her aid. Notwithstanding the fact that she lay sinking, and enshrouded in a dense sea fog, her dauntless operator was able to direct the rescue ships to the exact spot upon the waste of waters where she lay with her hull rapidly filling. At a later date came that most appalling disaster, the loss of the *Titanic*. By this time the distress signal had been altered to "S.O.S.," and all through that night of tragedy the wireless operator on the stricken giant was calling for aid.

The "Volturno"

More recently still "wireless" figures in the tale of the *Volturno;* on this occasion the danger was from fire as well as a high sea. Once more the "wireless" flung out its signal for help, and, though the vessel was comparatively small, and with a feeble installation, the message was caught up by the Cunarder *Carmania*, which, with her increased power, started flashing the evil news in every direction. It was caught up by other ships and again flung onward in one vast circle, until at last a veritable international fleet was hurrying towards the blazing emigrant ship. As a result the burning vessel, covered in flames and smoke, and tossed on a sea running mountains high, was surrounded by vessels great and small flying the flags of half a dozen different nations, ready at the first opportunity to launch their boats to the rescue. In these disasters we have three pictures that tell how greatly the invention of Chevalier Marconi has aided humanity. There are hundreds of other cases where "wireless" has been of inestimable use; more than one ship afloat to-day, and hundreds of men walking the earth, would now be at the bottom of the sea if wireless telegraphy had not been invented.

In other paths the Hertzian waves speeding through the air have played their part. Many a criminal, who has successfully eluded capture, and got to sea, has been confronted with the long arm of the law, which has been aided by the uncanny force that sends the dot and dash alphabet in successful pursuit. For the regular ocean traveller it has become an aid to banish the ennui of a long sea voyage. In all the large liners on the North Atlantic track a regular daily paper is printed and published, so that the passengers can read every morning of the great events happening upon the land astern, ahead, and on either beam, separated from them by hundreds of miles of sea.

For war purposes wireless telegraphy has worked a revolution, and more particularly in naval war. No fleet is now of the slightest use without it. From the largest battleship to the smallest torpedo craft (including a few of the submarines), all are now equipped with the device that signals without wires; and from the powerful installation on the roof of the Admiralty buildings in Whitehall, and the great station at Humberstone, near Grimsby, every ship round our coasts can be "spoken" and directed.

In actual use, during the naval war between Russia and Japan, it enabled Admiral Togo to keep his valuable battleships out of the dangerous area known to be sown with Russian mines; by using his light cruisers, equipped with wireless apparatus, he could still keep his eye upon the entrance to Port Arthur, and at the same time watch for the coming of Rodjestvensky.

In the air "wireless" has been fitted and used extensively, in the dirigibles of Germany in particular; whilst in all British sea-planes now being built a small, light, but efficient apparatus, will be carried as the result of successful tests made by our air pilots.

Truly, Chevalier Marconi can open wide his arms, and, looking at the world, claim that civilisation owes him a heavy debt indeed.

Denizens of the Deep

Concerning the Abounding Population of the Ocean and their Never-ceasing Warfare

By FRANK T. BULLEN

Author of "The Cruise of the 'Cachalot,'" &c.

VAST though the surface of old ocean may be, there is no portion of it that is not inhabited by abundant fish and their equally abundant food. No matter how remote from land your vessel may be, if she remains quiet for only an hour or two, little power of observation will be needed to see the surface population of the sea clustering about her. Indeed, it is not possible for a thoughtful mind to avoid arriving at the conclusion that these relatively small creatures feel lonely in the midst of that immensity of space, and seek with instinctive desire such companionship as a ship can give. I have even known of whales, not merely porpoises (whose love for accompanying a ship is well known) but whales of nearly a hundred tons in weight, judging from their size, lying by a ship for days of calm, and occasionally rubbing themselves against her as if by an impulse of pure affection.

I have also seen in the middle of the Indian Ocean, during a stark calm, a tiny crab, with a carapace not much exceeding a half-crown in size, alternately swimming and walking on the vessel's side. Not a strange uncouth species of crab, but just such a crab as any rock pool at your favourite seaside place will furnish. And at the same time there were to be noticed groups of well-formed, handsome little fish, in nowise *outré* to behold, but clustering closely round the rudder, not in the least scared by the great noise it made, now and then, as the vessel lifted upon a casual swell. It often gave me much food for meditation—where did these cowering little beings come from, and how did they fare when a breeze plucked their great shelter, or whatever we served for, away from them. It is a problem I have never known to be solved.

A Five-ton Catch of Albacore, with Rod and Reel, at Santa Catalina Island, California

Photo Ballou

Of course, every old-time sailor knew and loved the many pelagic fish, such as dolphin, bonito and albacore which came, so gleefully, under the bows as the vessel surged along through the trades. Catching them from the jib-boom was one of the delights of deep-sea sailing, and few, indeed, are the folks ashore who can realise how grateful and comforting were the succulent steaks of fish baked in fat after the long and dreary diet of appallingly salt beef and pork. The chief beauty of these fish to us was their being met with in the deepest water, as long as that water was fairly warm, so that we could thus alleviate our otherwise hungry condition.

From personal experience in many remote parts of the sea, I have no doubt whatever that, could we have ventured on a little scientific fishing, we should have been rewarded by many more species than the three I have named; as it is, I have known of barracouta and yellow-tail, both caught far from land in the deepest of blue water. Flying-fish, of course—although sea conditions forbid any systematic fishing for them. Still, the occasional belated wanderer that does fly on board, unless caught by the ship's cat, is, indeed, a sweet and welcome morsel, and would be anywhere. Incidentally, I may mention that for an enormous majority of the larger pelagic fish the flying-fish furnishes the bulk of their sustenance; the rest is practically made up of the ubiquitous cuttle-fish or loligo, which is found on the surface all over the oceans.

The Food of the Whale

But this brings me to a consideration of what, perhaps, is the most marvellous of all the pelagic fish, the myriads of tiny crustacea which furnish the food of the great whale of the Arctic seas, but are not confined to those icy waters. As might be expected from the part they play in the vast economy of the ocean, these creatures are found in incalculable numbers massed together. From the mast-head their serried lines, many feet wide, reach to the horizon. They appear as blood-red bands binding the globe, and must be many feet deep. Along these bands the sea-shouldering whale dredges his way, the wonderful mechanism in his mouth separating this tiny food of his from the sea, and an almost continuous current of writhing, tickling little shell-fish go gliding down that exiguous throat of his into the vast area of his stomach. How ever he manages in this way to keep up that enormous wealth of fat, thirty inches or so at the shoulder, is one of the miracles of Nature, of which one can only speak with bated breath.

Chief among the pelagic people of the sea is, of course, the whale in all his varieties, about which I have written in earlier articles, and to which I shall revert presently.

But the whale's attendant demands attention because he holds what is probably the chief place among pelagic fish. I allude to the shark. Perhaps I had better qualify what I have just said about his being attendant upon the whale, by saying that, although I have never seen a shark in attendance upon a school of whales, I have never seen a whale hurt without the appearance upon the scene, as if suddenly materialised, of many sharks. They vary in size, of course, according to the part of the ocean, the largest I have ever seen, nearly thirty feet long, being in the South Pacific.

Now, the shark may often be seen calmly gliding round a becalmed vessel in mid-ocean, engaged in the universal task of seeking food. He seems to know that there are possibilities of food attaching to a ship, and as he has no predilections, anything is welcome, apparently edible or not. But these are always single specimens, and give one the impression that sharks are very few. It is only when they are seen congregated round the body of a dead or dying whale that one realises their immense numbers. And when it is remembered that their reason for existence is that they fill the necessary office of scavengers, and scarcely ever catch living food, unless of a special nature, as when a man falls overboard, it becomes a source of amazement that there are so many of them.

Pelagic Population

The sun-fish, great helpless, useless creatures, unable to do more than just lie and bask on the surface, must not be forgotten, nor, although not a fish, can we pass over the turtle in silence, seeing that he is often met with sunning himself upon the calm ocean as remote from land as possible. And thus it will be seen, although the list is far from exhaustive, that the pelagic population of the sea is very great, and everywhere in evidence.

Ever since the undaunted heart of man discovered that the great plain of ocean could be utilised by him, he has perverted this magnificent privilege to the base uses of warfare. But from the earliest times, when the law of the strongest was the only rule that obtained upon the no-man's land of the ocean, until to-day, when the sea strength of Britain keeps the peace, and enables mariners of all nations to come and go upon their lawful occasions, the conflict of man with man upon the surface has been trivial, occasional, only indulged in within the severe limits set by the sea upon the intruder man. Compared with the daily life of its denizens, man's so-called tenure of the sea franchise is hardly to be noticed, so small and incidental is it, even as his frequent disappearance beneath the waves, with the latest and finest of his efforts for their subdual, causes only a momentary ripple among them.

A Cannibal Inhabiting Depths Five Miles Below the Surface

This nightmare of the deep has a luminous fringe to lighten the gloom of its surroundings. It habitually swallows fish larger than itself

But the stupendous, never-ending warfare of the sea-folk themselves, which is a law of their being, and without which they cannot live, needs an epic to describe even the remotest fringe of its all-embracing activities. Put as briefly as possible, it is the sole business of every sea creature (for the exceptions are really so insignificant as to be negligible) to kill and eat some other living creature, and thus a pyramid of interdependence is created, having for its apex the sperm whale, above the fear of any enemy but man, and its base—nobody knows where, down among the microscopic fauna of the sea.

Of that fierce collision between man and whale I have given instances elsewhere, both from personal experience and from the tales told by others, though your whale fighter is, singularly enough, one of the most reticent of mankind concerning his exploits. I have been in company with a dozen old whaling captains in Nantucket, not one of whom owned less than forty years' experience of the great game, but they would not or could not talk of anything but petty local politics which made one writhe to hear about. So that first-hand knowledge of the way of the ocean monarch when fighting for his life against his only foe is not easy to obtain.

Personally, I am compelled to believe that as an exhibition of gigantic strength nothing can compare with the upward leap of a sperm whale from the sea. It then appears as if the law of gravity were reversed, or as if the gigantic body were suddenly converted into an airship, so easily and lightly does it soar skyward, and so difficult is it not to believe that it hangs for an appreciable space of time in mid-air. Only the terrific concussion when it falls, shatters all such fancies instanter; there is then no sense of doubt remaining as to the reality and ponderousness of that stupendous mass. Such a sight in the broad golden sunshine is sufficiently impressive, heaven knows, yet I have heard of a case where the whole scene was rendered greatly more so because it took place at night.

Also, be it noted, that into this unceasing conflict altruism, not to say love, scarcely enters. Indeed, some of the fiercest foes of many genera are their own kind, who devour their offspring with the greatest gusto, all unconscious of any relationship. Earth affords no parallel to this, for even among the most ravenous creatures there is a law which forbids them to feed upon their own offspring, not merely when they are young and helpless, but when they have grown able to fight their own battles. And this law is only confirmed by the occasional breaches of it by frantic mothers, such as the rabbit and the sow under stress of some desperate fear.

In attempting to understand what goes on in the depths of ocean, we must needs call imagination to our aid, and add that to what we can see going on upon the surface. If the appearance of the deep-sea denizens be any guide to their habits, we are forced to the conclusion that they are not less but more fierce in their pursuit of each other. Verily, the aspect of most of them is apt to be terrifying, even to the accustomed observer, albeit only small and immature specimens are, or can be, brought to the surface in the deep ocean trawl. The full-grown specimens, with a gape large enough to take in a fish bulkier than themselves, must be appalling in appearance, especially when we know that they can and do devour bigger fish than themselves, gorging them as does a python its prey.

But the warfare which we are permitted to witness is sufficiently terrible. Watch an albicore (tunny) hurl himself into the midst of a school of bonito, smaller editions of

Drawn by H. Reynolds

Sword-fish Attacking a Cuttle-fish

While the latter is in the act of capturing a barracouta himself, and in a moment fill the adjacent sea with sanguinary fragments dropped in his haste to devour. Or the same bonito, having re-formed their company after the sudden onslaught, such as Gulliver might have made upon a crowd of Lilliputians (had no moral or ethical considerations restrained him), pursuing precisely the same tactics towards a school of flying-fish. Or the latter, having escaped the pursuit of their numberless enemies in the sea and their watchful bird foes of the air, busy recouping their strength by devouring their weaker kindred.

The Slaughter of the Herrings

But for wholesale slaughter which may be witnessed by ourselves, perhaps nothing equals that which befalls a shoal of herrings. They appear in countless masses, bent only upon visiting their favourite spawning grounds, and upon them prey all the sea-denizens larger than themselves with insatiable ferocity. How feebly futile are the adjectives—remorseless, relentless, ruthless—applied here. The aggressors have but one motive force—hunger; and, given the means of satisfying that, nothing else counts. From mackerel to man the great feast goes on, and by the bounty of Mother Nature there is enough and an immense overplus for next time. Only let it be remembered that most of this food is devoured alive; it goes down quick into the pit.

A grampus among a school of porpoises fascinates those privileged to witness the result, by the sheer immensity of its brutality. To see the huge sea beast swallowing alive a 200-pound porpoise, knowing the astounding vitality of the victim, and to realise that before the awful appetite of the grampus is appeased, a dozen or more of such huge morsels must glide down into its maw, is to instil a curious contempt for the devouring capacity of any land beast. But I have always felt a great curiosity as to how the walls of the eaters' stomach could stand the strain of holding a number of animals of such a size, while still alive, and capable each of amazing feats of strength. It is one of the many puzzles of the sea.

In this connection it must be noted that none of the sea-mammals, vast as their appetites are, and painful as their hunger must be, are ever scavengers—that is, eaters of things dead. Practically all fish are, although most of them prefer their food alive. I do not know of any that will refuse to eat things dead. Some even confine their attention to carrion, but these are the feeble folk of the sea. Where the carrion-eater has strength and ferocity like the shark, nothing comes amiss that he is able to obtain, however vigorously alive. Yet, as extremes meet, the much-abused shark, while living under the stigma of unimaginable ferocity, is one of the very very few fish that have a tender solicitude for their offspring, and is unique among the sea-people in that he has been able to inspire a beautiful species of mackerel with such affection that only the death of one of them can sever their association.

The Cuttle-Fish

Finally, we must not forget that in the immense economy of the sea, the cuttle-fish, in all its innumerable varieties, plays a most important part, perhaps the most important part of all, since it would be hard to name half a dozen useful species of fish for whom the cuttle-fish is not a staple food. That he is at the same time hideous and omnivorous may be set down as one of those secret decrees of Nature with which man has no concern, and in which, at any rate, he has no voice.

The Story of the Atmosphere

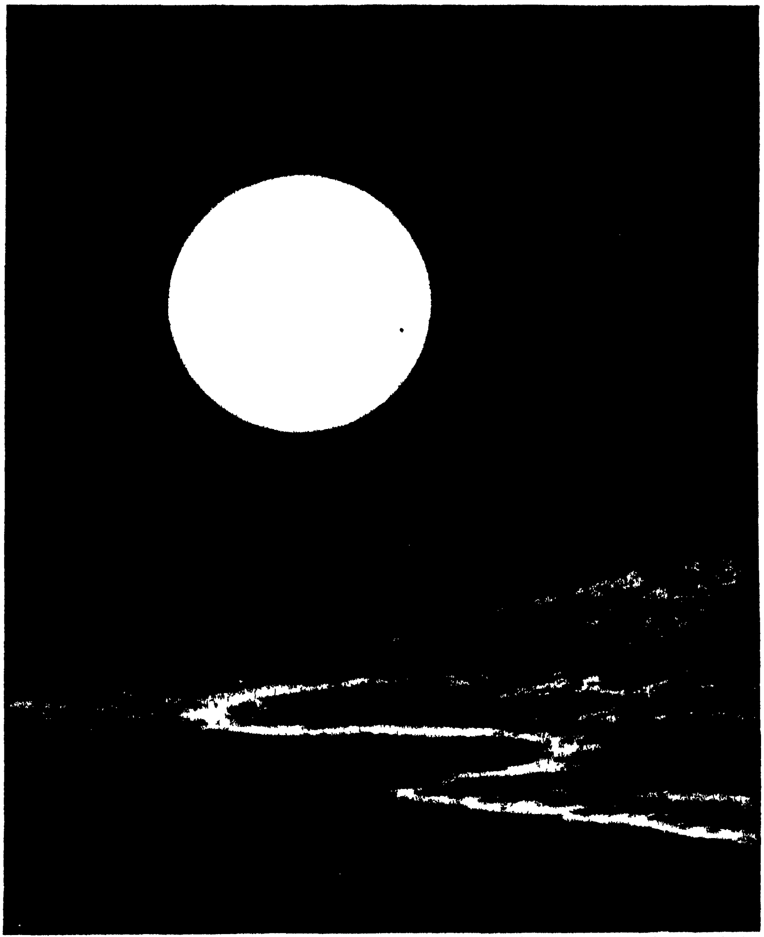
What Scientists have Discovered about the Air we Breathe

By ARTHUR HOLMES, F.G.S., A.R.C.S.

THE air we breathe does not usually invoke a feeling of wonder. It is the most obvious necessity of our life, and therefore, and rightly so, it is by most of us entirely taken for granted. We know, perhaps, that air can easily be weighed, and that it chiefly consists of oxygen very much diluted by nitrogen, but beyond these simplest of facts we ask no further questions.

Nevertheless, there lurks in the atmosphere a problem which is one of the most difficult that the geologist is called upon to solve. Where did the oxygen come from? It is not difficult for Nature to weave an atmospheric blanket around a world, for gases such as hydrogen, carbon-dioxide, and nitrogen are entrapped or occluded in all rocks and meteorites. Never a volcanic eruption takes place but a fresh supply of gases is liberated, presumably from the heated rocks below. But the remarkable fact remains: no *free* oxygen is ever supplied. Rocks and meteorites of all kinds have been heated, and their store of gases set free. In all parts of the world volcanic gases and the emanations from solfataras and fumaroles have been carefully analysed. In all cases where the air itself does not vitiate the results, oxygen is absent.

Is it possible that in the earth's original



Drawn by Scriven Bolton, F.R.A.S.

If Sirius Replaced Our Sun

Any considerable variation in the heat of the sun might have a fatal effect upon our atmosphere. If, for instance, it were augmented in size to equal Sirius (25 times larger) the earth would become red-hot, its atmosphere dissipated, and life on it impossible

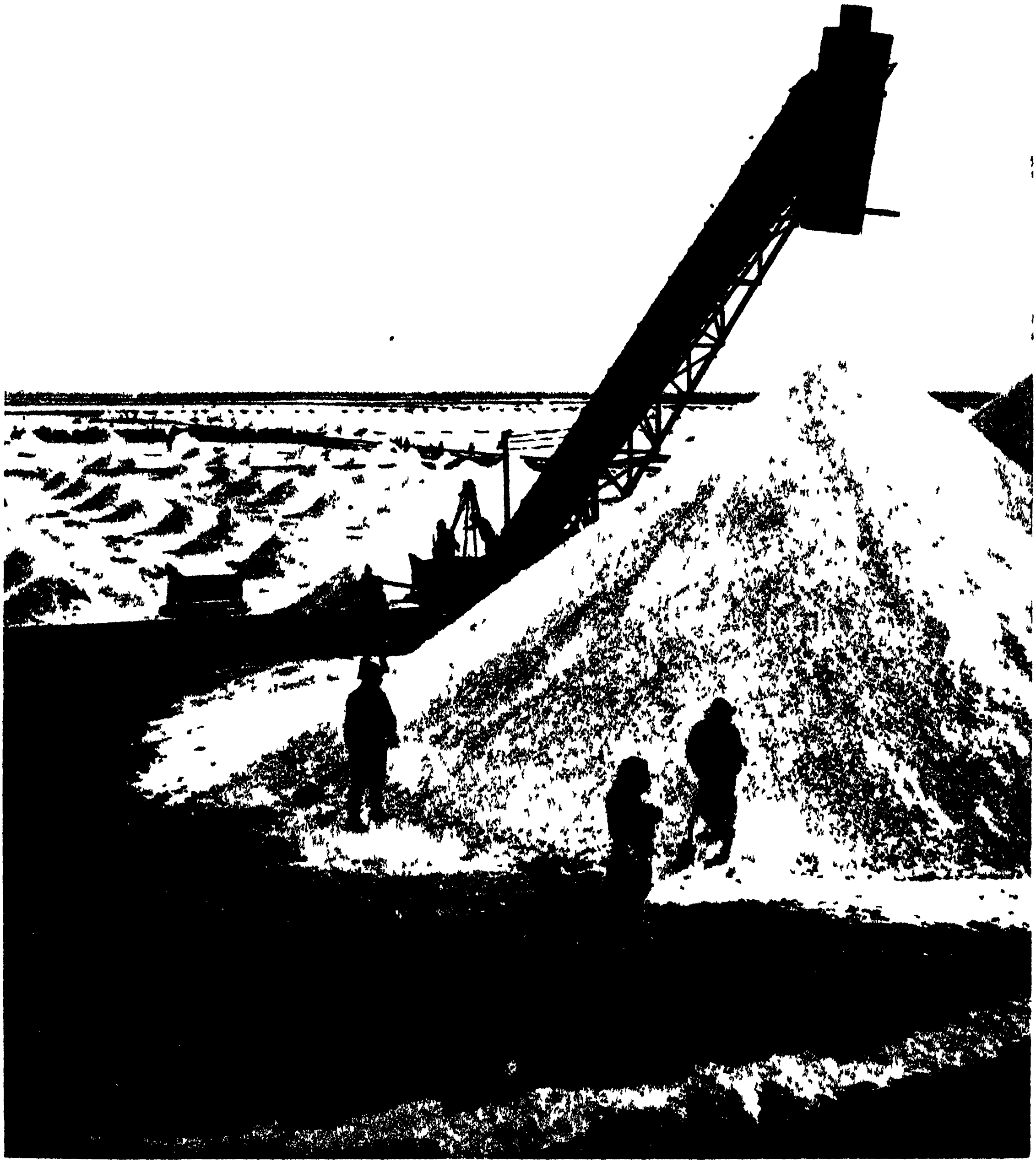


Photo by Galli

Where a whole Sea has Evaporated

At Benghazi, in Tripoli, Northern Africa, the salt industry is a considerable source of income to the inhabitants. This salt deposit marks the site of an ancient shallow sea, the waters of which have completely evaporated during many thousands of years' exposure to the burning sun atmosphere there existed vast quantities of oxygen of which the present stock is a mere residue ? Just as the rusting of a piece of iron demands the locking up of atmospheric oxygen, so does the weathering of a rock. In every part of the world the rocks are ready and anxious to add oxygen to themselves. Moreover, the respiration of animals is a constant drain upon the oxygen which is so essential to the working of the animal mechanism.

Oxygen Abstraction

These two great processes of oxygen abstraction – the decay of rocks and the maintenance of animal life —have been in action continuously for hundreds of millions of years. How is it, then, that any oxygen still remains ?

Fortunately, there is a balance of income and expenditure. Green plants inhale carbon-dioxide, of which there are normally four parts to ten thousand of the atmosphere, divorce the oxygen from its union with carbon, and liberate it into the atmosphere. There it is used by animals and non-green plants, and reunited with carbon to form carbon-dioxide. So the cycle goes on, and so delicately adjusted is the balance that with all our experimental devices we are unable to detect the slightest variation from year to year. Yet change there must be, for, quite apart from the demands of the teeming population of vegetable and animal life, certain gases tend to escape from the atmosphere altogether, and others are being freshly born into it.

The earth is able to control any body which leaves its surface with a velocity less than seven miles a second. If, however,. the speed exceeds this limit, the body becomes a voyager in space, independent of the earth, and unable to return. Now among the molecules of the lighter gases, such as hydrogen and helium, there are some which dart about at speeds in excess of this prodigious critical velocity. During the day, light exerts a minute pressure upon them, which is sufficient effectively to bar their way of escape. At night, however, the vigilance of the daylight has passed, and the more adventurous molecules start off into the universe on travels of their own. Thus the lightest gases are being lost to the earth. Fortunately, oxygen is one of the last of the gases to escape in this way. The heavier molecules are more sluggish than their lighter companions, and so their chance of an interstellar flight is correspondingly reduced. Hydrogen goes first, and helium follows close behind. Water vapour escapes more readily than nitrogen, and nitrogen has a slight advantage over oxygen, while carbon-dioxide is the last in the list.

On the other hand, each volcanic eruption implies an addition to the atmosphere, and yet among the gases no free oxygen can be found which was not previously in the atmosphere. Moreover, it seems impossible to liberate oxygen permanently by any other means than that which green plants employ. If we suppose that before plants existed either on the land or in the sea, there was a supply of oxygen already in the atmosphere, we are met not only with the theoretical difficulty of explaining how it got there, but also with the practical certainty that however much there was, it would have been eaten up by the rocks, and particularly by iron, which early in the history of the earth was probably much more abundant at the surface than now.

The Growing Earth

We are therefore obliged to believe that the young earth, while still growing, was incapable both of generating free oxygen and of retaining any with which it had been endowed during its earlier stages. The original atmosphere had probably two main sources. The stream of meteoric or planetesimal matter which built up our planet itself contained gaseous as well as solid matter, and this, no doubt, gradually accumulated around the growing nucleus.

Then, as the interior of the earth-mass became hotter, vulcanism was initiated, and the earth began to breathe out the gases and vapours which were imprisoned in the depths. Carbon-dioxide and hydrogen were the chief constituents, judging from the gases which the rocks actually contain. Nitrogen was probably emitted only in small quantities. It may seem strange that the atmosphere should be generated from rocks, yet there can be no doubt that the rocks were capable of supplying it. Even to-day an outer zone of the earth, 70 miles in thickness, would suffice to produce not only the materials of the present atmosphere, but in addition the water of the oceans and all the carbon-dioxide which is represented by limestones, coal, and all other carbonaceous deposits.

Generated from Rocks

Of the hydrogen of the primeval atmosphere, part would escape into outer space and part would help to form the ocean waters of those early times. Nitrogen has not played a very active part in the economies of our atmosphere. On the whole, it has steadily accumulated until the present day. It is in carbon-dioxide that the main interest lies. From it have been derived our great coal deposits, our limestone formations, and, most valuable of all, our oxygen.

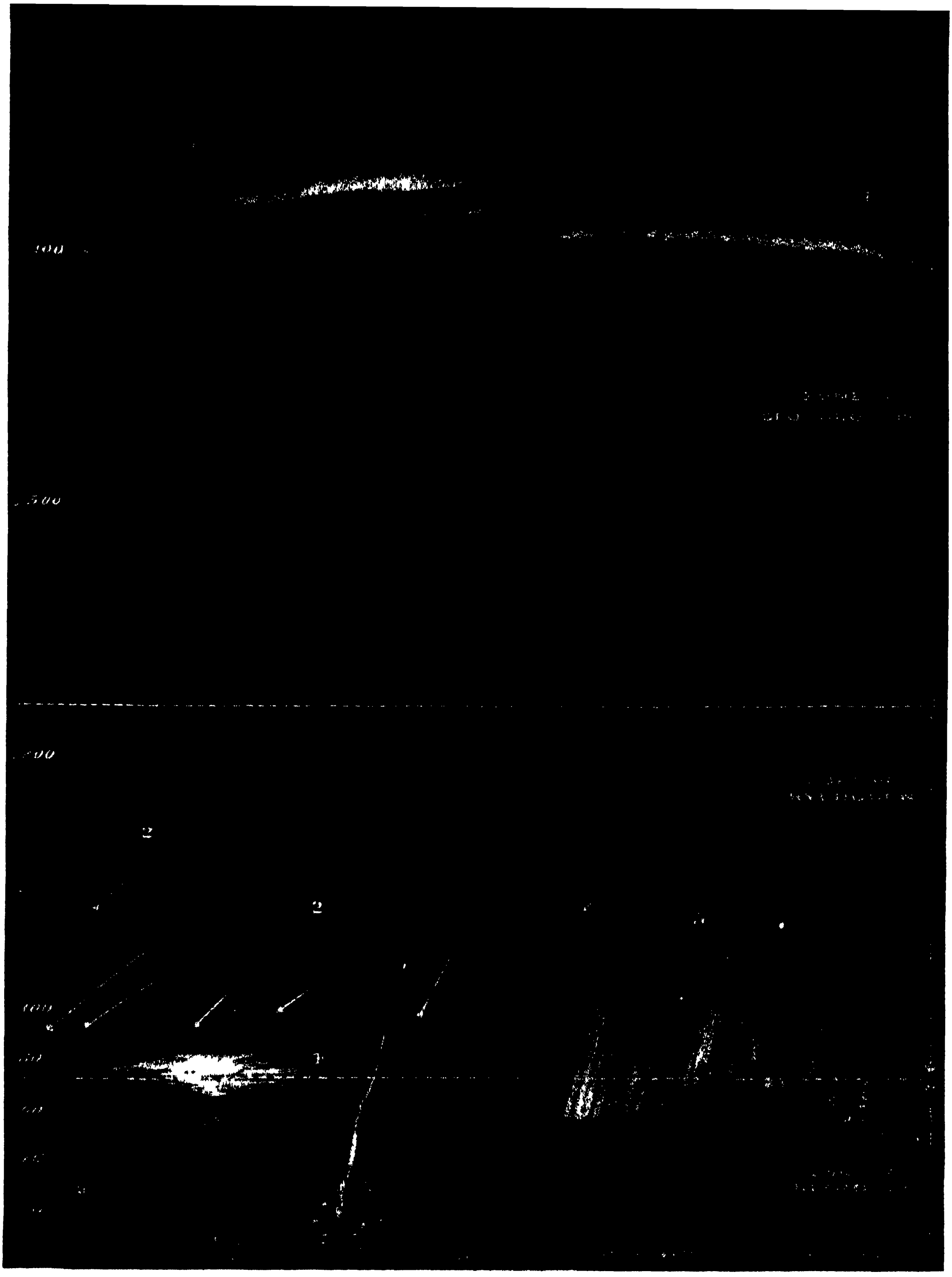
It was considered by the early naturalists to be an indubitable fact that life was not possible without oxygen. We know to day that it is. In many of the protoplasmic cells of plants and animals oxygen plays only a secondary rôle, and is, in some cases, quite unnecessary. Still more significant, there are non-cellular forms of life which can live and thrive in the absence of oxygen, and others again for which the absence of oxygen is not only desirable, but essential, for it is a poison to them. The need of oxygen appears to increase as the complexity of the organism increases, and this applies not only to life as a whole, but also to the personal history of an individual organism. These facts point to the conclusion that life was possible on the young earth before free oxygen had been liberated, and, further, that it must actually have begun in the absence of that element.

It is impossible to know what the earliest forms of life were like. It is generally assumed that they were similar to the non-cellular organisms of to-day, although that is merely a sentiment. However, we may grant, with some justification, that the earliest organisms were able to draw their nutriment from the air as it then was, the ocean, and the naked rocks; that they were not dependent on oxygen in their efforts to inhabit the earth; and finally that they prepared the sea bottom and the surface of the land for the plant life which later became possible.

Even to-day plants derive their food directly from the air and water and soil, though it seems to be essential that the soil must previously be prepared for them by bacteria. Then, when plants have developed, animals become possible, for the latter cannot live merely on soil and air, but require organic products which have previously been formed. The only possible order of life development thus seems to be from microscopic non-cellular organisms to plants and from plants to animals. This is so to-day, as was admirably proved in the case of Krakatoa (*see* p. 55). A totally new land surface was suddenly laid open to the sky, and the order of the life forms which inhabited the dismembered island was that just stated. It has also probably been true in the whole history of life on our planet, though, as was pointed out previously, there is no definite proof that the first organisms were non-cellular, as are the bacteria of to-day.

Order of Life Development

To return to our oxygen problem. As soon as the earth was ready for their



Drawn by W. B. Robinson

A Chart of the Chemical Composition of the Upper Atmosphere

According to Professor Alfred Wegener, of Marburg University, near the ground nitrogen is in the proportion of 78·1 per cent. to 20·9 per cent. of oxygen. At 20 km. (12 miles) there is 85 per cent. of nitrogen and only 15 per cent. of oxygen. At 100 km. nitrogen has practically disappeared, while there is 55 per cent. of hydrogen. Now appears another gas which Prof. Wegener identifies with the coronium of the solar atmosphere, and which he has named "geocoronium." These conclusions are arrived at by studying certain phenomena of sound; by the spectra of (1 and 3) the Aurora Borealis, (2) shooting stars, (4) luminous clouds caused by dust in suspension, and (5) bolides; and by means of (6) sounding balloons reception, plants began their long life history, and with them came the first possibility of oxygen as a permanent constituent of the atmosphere. The green material, chlorophyll, of plants, absorbs certain of the rays of sunlight, and in some way utilises the energy to break up the molecules of carbon-dioxide and water. When the plant has served its purpose, a little oxygen is left over, and this is breathed out. The green algæ of the oceans are more efficient workers in this respect than most land plants.

How well the plants have done their work is testified by our own existence to-day, and by the commercial prosperity which has everywhere followed the discovery of coal. Coal is the predominant example of a formation, the carbon of which was once united with the oxygen, or part of it, which we breathe to-day. There are nearly 1,100 million million tons of free oxygen in the atmosphere to-day, and 300 million million tons of carbon would suffice to reconvert this to carbon-dioxide. As a matter of fact, there is, in the earth's crust, at least ten times as much unoxidised carbon, indicating that not more than a tenth of the oxygen which has at one time or another been liberated is still in the free state. It is, indeed, remarkable that there should be any free oxygen at all, for the earth has an unsatisfied hunger, and only the endless struggle which the plants keep up enables the animal world to flourish without being menaced by the danger of oxygen starvation.

Tropical Palms—some of Nature's Efficient Oxygen Factories

J F & S hitterton

The Golden Eagle

The Bird King of the Scottish Highlands lives in the most grand and inaccessible regions of the hill country, where the foot of man rarely penetrates

The Golden Eagle

Bird King of the Western Highlands

By SETON GORDON, F.Z.S.

LIVING, as he does, in the most grand and inaccessible regions of the hill country, where the foot of man but rarely penetrates, the golden eagle is a bird little known to any save those whose time is spent in the country of the glens and corries. Since time immemorial the eagle has stood for courage and strength of character to the hillman. To him the bird is known as the Black Eagle, or, in the language of the hills, as "Iolaire Dubh." Again, sometimes he has been named the "Great Bird," or "An-t-Eun Mor." Perhaps the most remarkable charm of the eagle lies in his flight, which is unrivalled amongst our birds.

"Iolaire Dubh"

To see this power of wing at its best one must penetrate to the high hills during a day of fierce wind, and, may be, of driving squalls of hail and snow. On one such day in autumn I watched for some time a golden eagle, and was immensely impressed with the complete control over the elements which the bird possessed. He was soaring just above the summit of a hill nearly 4,000 feet in height, where the wind must have been blowing at a rate of quite 45 miles an hour—probably more. For a little time he remained more or less stationary in the teeth of the wind. Then closing his wings lightly he dropped earthward like a stone for several yards before once more spreading his pinions and rising—with never a movement of the wings, that is the most interesting part—to his former elevation. This feat he repeated several times, evidently taking pleasure in his battle with the storm.

On another occasion I nappened to disturb a mother eagle covering her eggs. Her eyrie was on a Scots pine in an exposed part of a hillside, and a strong wind was blowing straight into the nest. As I approached the tree the eagle shot out into the air, and, rising almost perpendicularly and with great speed, showed her soaring powers to the full. But perhaps the most remarkable exhibition of soaring it has been my good fortune to witness was on a certain occasion when I chanced to be in a wooded glen where a pair of eagles have been in the habit of nesting for many years. A stiff northerly breeze was blowing at the time, and, flying low against this breeze, an eagle crossed the ridge. Soaring out into the wind he now commenced to rise, gradually and steadily, leaning on the wind, but never moving his wings except to steady himself. Hidden at times by passing clouds, he reached an elevation at which he was visible only through the glass, but at length I was unable to follow him even with the aid of the telescope. This, I think, speaks for itself, for a bird with a spread of wing of six feet is prominent even at a considerable height.

The eagle's love of sport is well marked. At times after capturing a ptarmigan he will rise to a great height and will let his prey drop. For a second or two, may be, he sails round, apparently unmindful of the falling victim, but suddenly, closing his wings, he shoots earthward, easily overtaking the ptarmigan before it has reached the ground. Then, perhaps, the whole evolution is repeated several times before

Love of Sport

the captor makes his way to some prominent rock to commence his repast.

Whether or not the ancient tradition, to the effect that an eagle can look straight into the sun, is well founded, is difficult to say. As the photograph shows, the eagle possesses a well-marked third eyelid, which was drawn over the eye at the instant when the plate was exposed. This third eyelid is a film of skin which is drawn horizontally across the eye, especially, I think, when the bird is alarmed, and must also be of service in cleaning the eye. It is quite possible that when looking at intense light the bird retains the third eyelid spread across the eye, but as far as my personal experiences go the eyelid is merely passed across the pupil with extreme rapidity and then withdrawn. There is no doubt that both adult and immature birds pass it constantly across the eye when annoyed or alarmed.

Photo Seton Gordon

The Third Eyelid

Whether or not the third eyelid is used as a protection while on the wing, it is certainly the case that on one occasion, at least, I have seen a golden eagle soaring easily and confidently against a fierce blizzard of dry, powdery snow swept swiftly across the hillside by a strong wind. In my comparatively sheltered position at the foot of the glen it was literally impossible to look into the storm for more than a few seconds at a time, so the sight of the eagle making his way swiftly and easily in the face of the snow was striking evidence as to the power of his vision.

Considering the exposed situation of the eyries the nesting season of the eagle is early. On the lower grounds, that is from 1,000 to 2,000 feet above sea-level—for in Great Britain I have never known the eagle nest below the 1,000 feet line—the eyrie is repaired during the months of January and February, and by mid-March the hen bird is covering her two eggs. The young are hatched out early in May, and are tended for some nine weeks in the eyrie before making their initial flight. They are fed chiefly on grouse, with rabbits—when these are present in the neighbourhood—and mountain hares. In the Crimea, where I saw no less than seven eagles in the air together, the birds are forced to live on the smaller birds, owing to the absence of what is their prey in the British Isles.

I have on several occasions been witness of the first flight of an eaglet from its eyrie. In one instance the youngster flew a considerable distance up the valley, helped by a slight following wind. He lighted on some long heather, and, being now at the foot of the glen, had not sufficient power to raise himself from the ground; after a time his flappings amongst the long heather brought him to the banks of the hill burn—at a point where the water was several feet deep. To my surprise the eaglet unhesitatingly jumped into the water, and, using his wings as oars, successfully crossed the pool, and emerged, dripping and draggled, though unharmed, on the farther bank.

Drawn from photographs by F Matania

Capturing Eagles with Decoys in China

Every year thousands of Chinese go into Mongolia to catch eagles, the feathers of which are used for expensive fans. They employ tame eagles, which they carry on their shoulders. At certain spots nests are arranged and baited with fishes. The tame eagles are soon joined by hungry wild ones, over which a net is flung by hidden trappers

Meteorites

Concerning the "Great Stones from Heaven" which have Puzzled Earth's Inhabitants for Thousands of Years

By ARTHUR HOLMES, F.G.S., A.R.C.S.

Author of "The Age of the Earth," &c.

FALLS of stone from the sky have been recorded in many of the most ancient of human documents, but so incredulous were the early scientists that it was not until the close of the eighteenth century that the facts of the phenomenon became recognised. Probably the earliest fall known to history is that referred to in the tenth chapter of Joshua, where it is stated that "the Lord cast down great stones from heaven." The Chinese have records of meteoric displays stretching back to 644 B.C., and Livy relates that about 652 B.C. an impressive fall took place near Rome.

A Shower of Meteorites

The point from which they radiate is called the radiant point

Many of the stones which the ancients preserved as undoubted meteorites were regarded with such awe and reverence that they came to be worshipped. One of the most famous stones of the olden world fell in Phrygia, where it was preserved for hundreds of years as Cybele, the mother of the gods. In 204 B.C. this image, which was a black, conical stone, was transferred to Rome in the hope that the welfare of the State would be guaranteed by its presence. The Diana of the Ephesians "which fell down from Jupiter," was probably a conical meteorite and not, as popularly supposed, a beautifully carved statue. One of the holiest relics of the Mahometans is a meteoric stone which is built into the Kaaba at Mecca. A stone which fell in India, about thirty years ago, was wreathed with flowers and anointed with scented oils, and at the shrine which was afterwards erected for its preservation a ceremonial service was instituted in its honour. This stone is now to be found in the pavilion devoted to the nation's superb collection of meteorites in the Natural History Museum.

In the little town of Ensisheim, in Alsace, there still remains a famous meteorite which fell there more than four hundred years ago. The Emperor Maximilian was in the district at the time, and, being greatly impressed by this seeming miracle, he ordered a careful account of the fall to be written, which reads as follows :—

"In the year of the Lord 1492, on the Wednesday before St. Martin's Day, November 7th, a singular miracle occurred, for between eleven o'clock and noon there was a loud clap of thunder and a prolonged, confused noise, which was heard at a great distance, and a stone fell from the air which weighed 260 pounds, and the confused noise was at other places much louder than here. Then a child saw it strike on ploughed ground . . . which was sown with wheat, and it did not harm except that it made a hole there. They caused it to be placed in the Church, with the intention of suspending it as a miracle, and there came here many people to see this stone, so there were many remarkable conversations about it; the learned said they knew not what it was, for it was beyond the ordinary course of Nature that such a large stone should smite from the height of the air, but that it was really a miracle from God, for before that time never was anything heard like it, nor seen, nor written."

The Williamette Meteorite

Found in Oregon, U.S.A., in 1902 It measures 10 ft. in length and 6 ft. 6 in. in height, and weighs 15½ tons

Three centuries had yet to elapse before scientific men began to realise the celestial origin of meteorites. The German philosopher, Chaldni, was the first to study these objects from a rational point of view, and although he decided that they must necessarily have fallen from the sky his arguments failed to procure a favourable reception. These "sky-stones," so different in all their characters from the rocks found *in situ* all around them, were accounted for in many curious ways. Some of those who rejected the simple faith in their miraculous origin believed that they were generated in "an igneous mass of clouds which produced much unusual thunder." Others suggested that these remarkable clouds were mixed with pyrites and iron, blown into the sky from the orifice of a volcano. Lavoisier and his colleagues confused the brilliant ball of light which marks the passage of a meteorite through the atmosphere with the so-called thunderbolt. To them it was merely a rare and dangerous variety of lightning, and the stone which was found where the fire-ball struck the earth was supposed to owe its peculiarities to its having been struck by this extraordinary electric discharge. However, in 1803, the French mineralogist, Biot, investigated a great fall of stones in Normandy, and his evidence exhaustively proved their extra-terrestrial origin.

Now that the scientific world was compelled to admit that meteorites come from the outer realms of space, these stones became of the greatest importance. They, alone, enable us to study in the laboratory materials which are born in other worlds than ours. What do we know to-day of their origin? Many theories have been put forward during the last hundred years, but none, it must be confessed, is wholly satisfactory. Stones are often hurled to an enormous height by volcanoes, but so retentive is the earth that, even ignoring the resistance of the air, a projectile would require an initial velocity of seven miles a second in order to pass successfully out of her jurisdiction. True, a stone once emitted from the fiery throat of a colossal volcano with such a prodigious velocity would necessarily cross the earth's track again and again until it was picked up as a meteorite; but no velocities of this amazing order have ever been approached by volcanic emissions, and, moreover, the mineral characters of meteorites are different from those which make up the vast majority of our crystalline rocks.

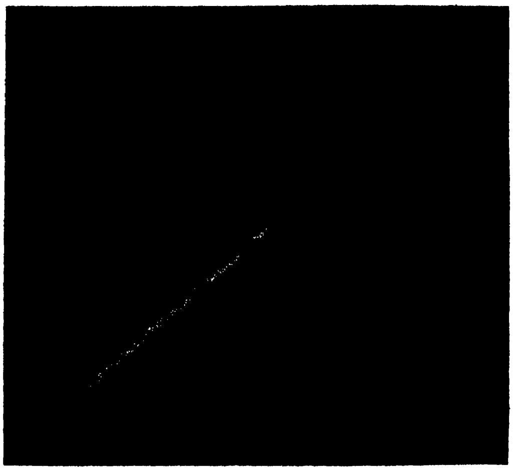


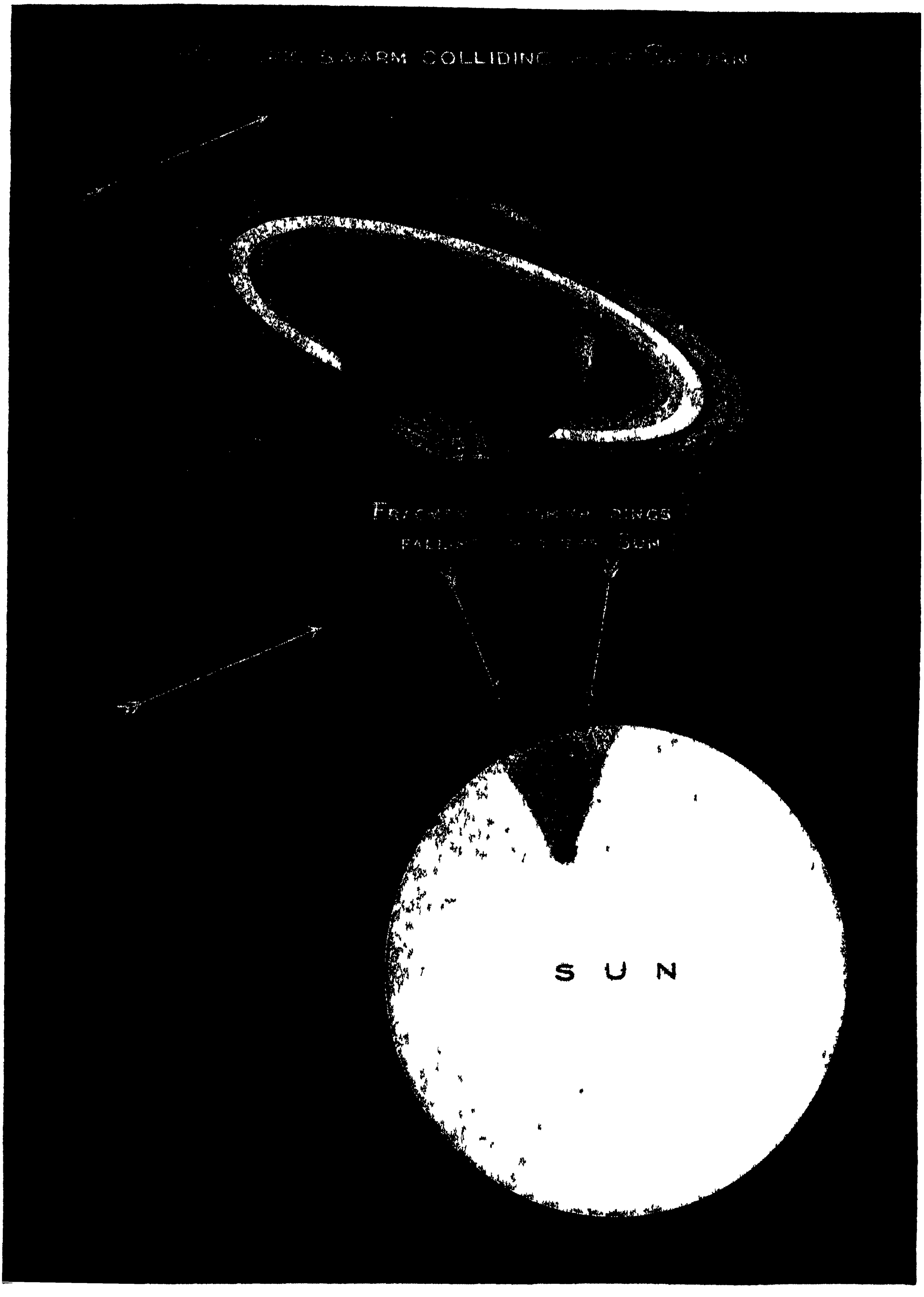
Photo kindly supplied by C. P. Butler, Esq.

An Exploding Meteor

If, then, our meteorites cannot have been discharged from the earth, may they not have been projected from volcanoes on the moon or on the planets? Have they been ejected from the sun or stars, or may they, perchance, be the relics of an exploded planet or satellite or the outlying remnants of a disrupted star? Are they the scattered constituents of a disintegrated comet, or have they collected in the wide domain of space from fine particles of matter, as raindrops gather in the atmosphere?

Let us look at the meteorites themselves and see what their peculiar characters seem to signify. Many meteorites are stones formed largely of minerals, such as olivine and bronzite. Others are almost entirely metallic and are composed of an alloy of iron and nickel. Still others partake of the characters of both these classes; some have the stony minerals embedded in a metallic matrix; some have the nickel-iron disseminated in a mineral ground mass. When first found "sky-stones" are generally enveloped in a thin, glossy coat, and most of them are curiously pitted with holes. These superficial features are born in the wild rush with which the meteorite dashes through the atmosphere before coming to earth.

At the time the meteorite is first seen it is already stretching across the sky a brilliant streak of light. Invisible and cold as it takes its flight through the unimpeded freedom of space, it plunges into an ocean of air, which meets it with a terrific resistance. Its initial velocity—anything from ten to forty-five miles a second—is rapidly



Are Meteorites Responsible for Sun-spots?

(*Drawn by Scriven Bolton F R A S*)

Mr. Scriven Bolton here illustrates a theory formulated by Prof H. H. Turner, F.R S , who suggested that sun-spots are formed by fragments struck from Saturn's rings (which are in themselves nothing more than a great meteoric swarm) by the swarm of meteors known as the Leonids, which fragments fall into the solar furnace at a speed of 400 miles a second

reduced by the brake of atmospheric friction, and an enormous amount of heat is generated. In less than a second or two the meteorite disappears except in very rare circumstances; it has been fused and reduced to vapour, and those who see it exclaim, "There is a shooting star!" The larger ones invariably explode, and should their size enable them to resist the furious temperature in which they are suddenly bathed, they may perhaps reach the earth. The fall in Normandy which was investigated by Biot consisted of over two thousand stones, many of which were still hot when found, and one of which burnt the arm of a man whom it struck.

Shooting Stars

The largest meteorite known is one which fell in Mexico and reached the ground still weighing over 50 tons! So great is the fusillade of meteorites with which the earth is bombarded that Arrhenius has estimated that each year's capture amounts to 20,000 tons.

What, then, becomes of this enormous quantity of cosmic dust which is picked up by our planet? Fortunately, most of the particles never reach the ground except as the finest powder. Were it not for the cushion of air which protects us from these celestial bullets, our globe would be quite uninhabitable. Could we rise in an aeroplane a hundred miles above the earth's surface we should meet with myriads of "shooting stars," each rushing headlong through the attenuated air with a reckless speed two thousand times that of an express train! But the plunge into the atmosphere is fatal, and all except the largest perish in a brilliant blaze of light. The dust which condenses from their vapour, which may readily be detected because of its unusual metallic composition, is found on the white snows of the Alps and of other high mountain ranges. Polar explorers have found it in the frozen heart of the Arctic and Antarctic regions. Oceanographers have brought it up from the deepest recesses of the ocean floor. Even on cathedral towers it may be detected. Everywhere the thin rain of meteoric dust proceeds unceasingly.

Reverting to the stones which actually reach the earth without being vaporised, we find in them many significant and yet apparently contradictory features. Some of the iron meteorites are crystallised on so massive a scale that only very great pressure and slow cooling could have made it possible. Moreover, the nature of the crystals tells us that the temperature must have been over 860° C.

In other meteorites a mineral, tridymite, is sometimes found, which betrays the temperature of its formation to have been between 800° C. and 1,620° C.

On the other hand, many stony meteorites contain a dark basic glass, which implies very rapid cooling. Still more extraordinary and confusing is the occasional presence of combustible hydrocarbons—substances which forbid any possibility of a high temperature throughout their history. These volatile constituents have survived the great heat of the journey through the air because they were preserved in the cold interior of the meteorite's heart. Bearing, within themselves, the cold of outer space, many meteorites are found, soon after their fall, to be coated with frost; they have, indeed, been facetiously likened to "fried ice"—a masterpiece of Chinese cookery.

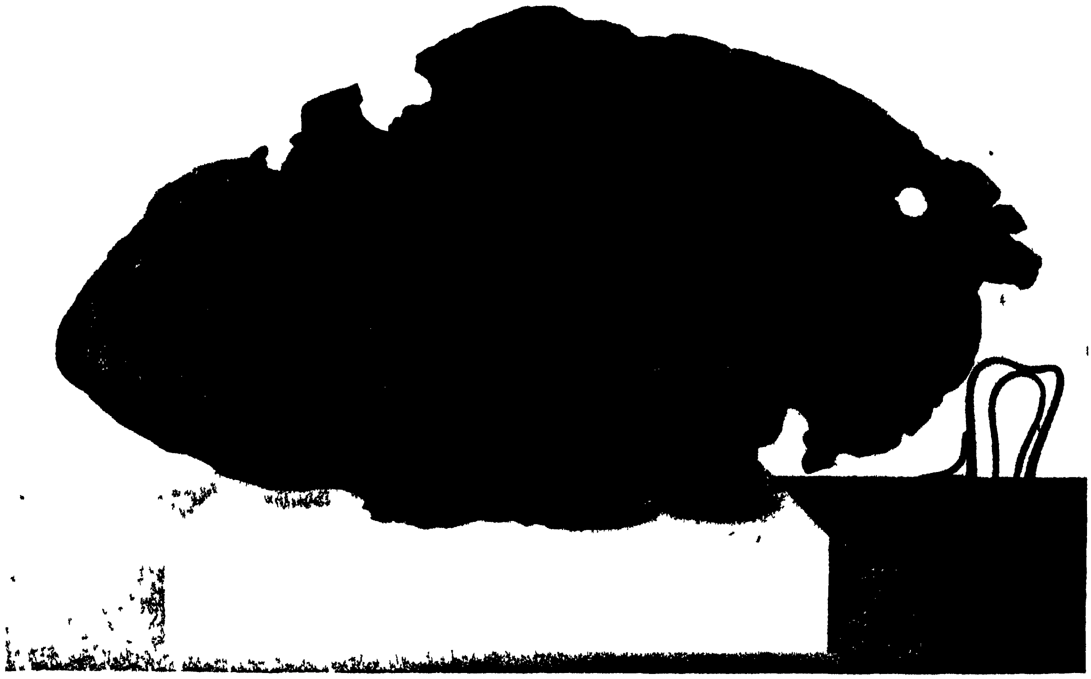
A Parent Body

These features all point to a meteoric parent body in which a great variety of temperatures and of rates of cooling was possible. We further find that meteorites, themselves fragmental, are sometimes made up of smaller fragments. Slickensided surfaces and even veins of mineral matter suggest a parent body in which fracture and movement took place much as they do in the crustal rocks of our own planet. The invariable absence of such minerals as quartz and felspar, as well as of water and free oxygen, points to the absence of rain, rivers, and oceans, and the lack of an atmosphere such as ours.

Finally, the whole of the evidence, taken together, leads to the conclusion that meteorites arose from the disruptive shattering of a small cosmic body free from blankets of air and water, such as those which envelop the earth. The stony meteorites suggest that they are derived from the outer layers of the parent body, while the metallic ones probably come from the deeper regions—perhaps from a dense iron nucleus analogous to that of the earth. The interior of this unknown body cooled slowly, and made possible the coarse crystals of nickel-iron. The outer crust, unguarded by an atmosphere, cooled rapidly, and so became readily fractured. Volcanic action evidently took place, and the absence of water is no objection to this suggestion, for the meteorites contain within themselves gases ample to provoke the most violent volcanic paroxysms.

The postulation of a parent body of this kind is capable of explaining all the broader peculiarities of meteorites. That such bodies exist is undoubted, for the asteroids and many of the satellites of the planets would readily satisfy the conditions. Beyond this, however, it is impossible to discuss the history of so hypothetical a parent.

There only remains to discuss the way in which this hypothetical body was exploded and its fragments cast abroad as meteorites. Actual collision with another body would be fatal, for extreme pulverisation and extreme heating must evidently be avoided. The conditions would, however, be satisfied by the close approach of some other larger body. The smaller one would then be torn into fragments, which would afterwards be compelled to follow the paths prescribed to them by the sun, until, at last, they cross the track of the Earth and are gathered to it as a brilliant shower of shooting stars, or as a more imposing fall of meteorites.



Another View of the Williamette Meteorite

Observe the deep pits caused by oxidation

The Hornet and Its Nest

By HAROLD BASTIN

Author of "Insects Their Life-Histories and Habits," &c.

STRICTLY speaking, the hornet is neither more nor less than a big social wasp. A small hornet is larger than the largest wasp, and its livery is brown and yellow, whereas that of the wasp, so-called, is black and yellow.

What is the significance of all the activity towards the end of summer about the hornet's nest, and how did it originate? To answer this question we must first cast our minds back to the spring of the year, when a solitary "queen" hornet (whose nuptials were celebrated in the preceding autumn) came forth from her winter hiding-place. She it was who laid the foundations of the nest—or, more correctly, made preparations for suspending it from some suitable support. For the habitations of the hornet (and of the wasps) are built from above downwards, with the result that the whole structure appears to be topsy-turvy when viewed with human eyes. The hornet builds, as a rule, in hollow trees, or in the roofs of outhouses, barns, etc., though it occasionally nests in holes under the ground. The material used is really a kind of paper—to wit, the fibres of rotten wood worked up with the insect's sticky saliva.

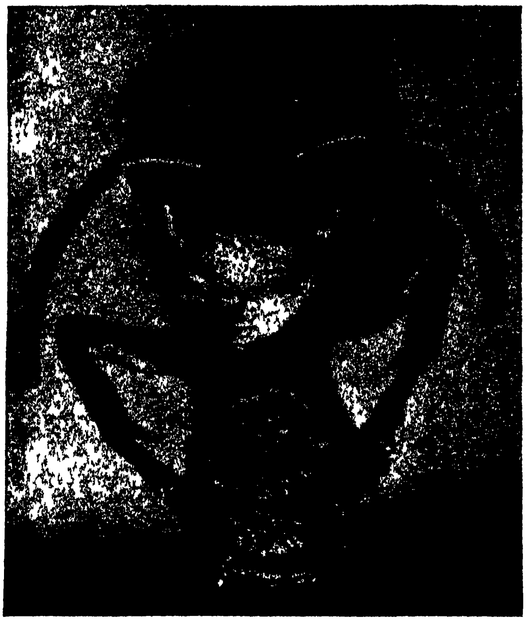


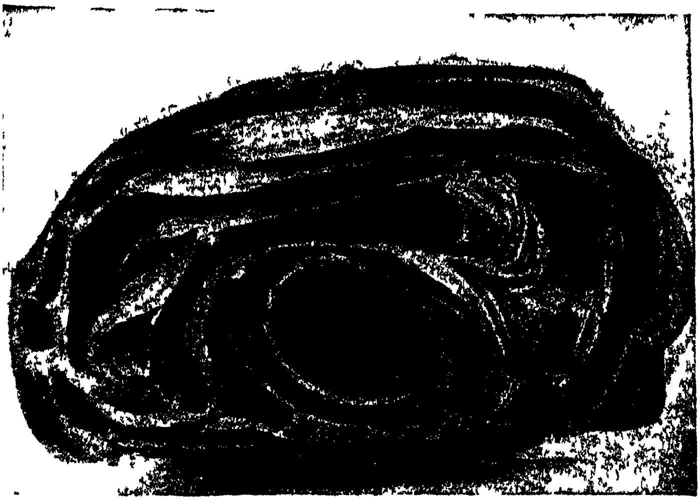
Photo: H Bastin

The Face of a Hornet

The hornet is clinging to a twig

The solitary queen makes a few shallow cells, and at once converts them into nurseries by laying an egg in each. When the eggs hatch she feeds and nurtures the young grubs with the utmost care, filling in odd moments by continuing her building operations. Ere long the first-hatched grubs change to pupæ, and eventually appear as fully-fledged hornets; and with their advent we reach the strangest point of the whole story. These offspring of the queen, though definitely feminine in sex, are not exact counterparts of their mother. They are smaller, practically sterile, and their activities are governed by a unique set of instincts which impel them to labour ceaselessly for the good of the community as a whole. They at once begin to enlarge the nest and care for the grubs, leaving their queen-mother free to augment the population by laying each day an amazing number of eggs.

The result of this arrangement is without parallel (except by other insect communities) in the whole animal kingdom. Instead of producing a few isolated beings exactly like herself, the queen hornet becomes the mother of a huge association which, for all practical purposes, functions as a single individual. This view of the case is amply justified by the fact that a worker hornet, permanently exiled from its nest, becomes a meaningless item in the economy of Nature. It can neither reproduce itself, nor justify in any other way its right to live. The complete community, on the contrary, is an "intelligible proposition."



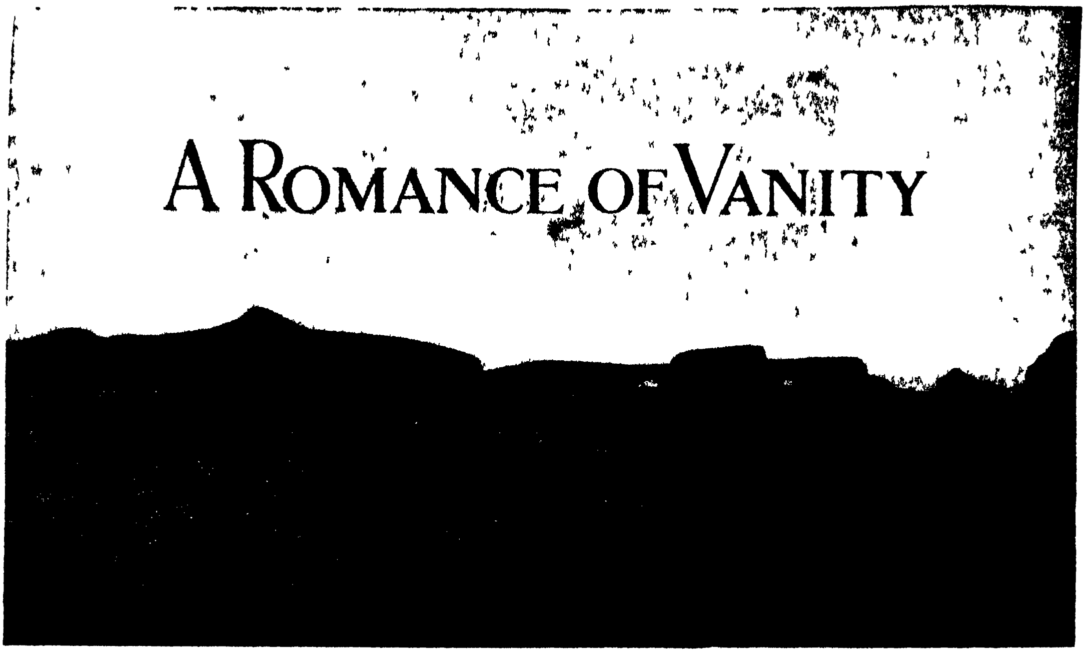
Throughout the summer this machine steadily increases in size and capacity. But the first frosts of autumn check its progress. Hornets lack the art (so wonderfully perfected in the case of the hive-bee) of storing up provisions for winter use. They never bring to the nest more food than is needed to provide the grubs with their daily ration. Thus, when winter approaches, and food becomes scarce, they quickly succumb to cold and starvation. Before this special "royal" cells have been prepared as nurseries for a brood of males (or drones) and young queens. After pairing has taken place, the drones soon perish; but the queens repair to snug hiding-places, where they lie dormant until the following spring. Each of these hibernating queens may be regarded as a kind of seed, from which in due season a complete hornet community will issue.

Photos

Three Views of a Hornets' Nest

Found in the roof of Mr. Thomas Alexander's house beside the Kennet and Avon Canal

A ROMANCE OF VANITY



Photos by permission of the Peruvian Corporation Ltd

The Guano Islands, off the Peruvian Coast

What the World's Wheatfields Owe to the Sea-birds of Peru

THERE is this to be said for vanity, that we owe to one of its gewgaws the fertility of a great part of the cultivated earth. There would be to-day vast wastes of barren, exhausted soil had not woman claimed for her personal adornment certain curious fossils which the medicine-men had at last rejected; for from an analysis of those ornaments arose the whole science of agricultural chemistry, of which the rich industry in nitrates is one expression.

In days when our grandmothers were girls it was the fashion—pearls and diamonds being then less plentiful than is now the case—to wear, in the form of earrings and brooches, singularly marked stones which were found, among other places, in great abundance along the seashore at Lyme Regis. The attention of Dr. Buckland, Dean of Westminster, was, upon a day, drawn to one of these earrings. He noted on it certain curious groovings, and obtaining its removal from the pretty ear by which it was adorned, submitted it to careful examination. His investigation led to experiments, on a wider scale, upon all the brooches and ear-rings of the kind to which he could lay his hand.

His experiments proved that the much-prized ornaments adorning the necks of the belles of the age, dated back to the era of the colossal reptiles and fish-lizards which owned the England of the misty dawn of unnumbered millions of years ago.

They were fossil forms of organic matter—coprolites. They contained the scales and teeth and bones of prehistoric fishes; bones and smaller fragments of lesser saurians. They were coloured by the sepia-bags of countless cuttle-fish eaten before man emerged from the chaos of his pre-mammalian ancestry. The pretty stones which the beauties of the period were using as charms and jewels, which the wizards and surgeons of a bygone era had employed in medicine, were, in fact, nothing but fossil guano.

The discovery of the worthy Dean struck dead the traffic in the fossil wares of Lyme

Regis as jewellery, but it immediately opened out a new and greater trade. The Dean caused some of the ornaments to be ground up. The future Lord Playfair pulverised them in his laboratory, and found, as the Dean had predicted, that they were rich in phosphates of lime, the one substance most needed for restoring fertility to our exhausted soils. Very soon afterwards Baron von Liebig, the great German chemist, visited England, and was taken by the Dean and Playfair to see the fossil riches of Lyme Regis, and the Dean expounded his theory of renewing the face of the earth by exploiting its contents of fossil guano, the product of the meals of the monsters of millions of years ago. The illustrious German took the hint, published a treatise upon the subject, and, aided by these two Englishmen, established the enormous industry in superphosphates which has restored fertility to millions of acres of land which were on the point of barrenness, and has kept in cultivation still vaster tracts of land which, but for such replenishment, must long ago have become reduced to desert conditions. This colossal industry, with its incalculable effects in the feeding of humanity, took its rise in the ear-ring worn by a pretty girl known to the gallant and scientific old Dean.

A Barren Spot

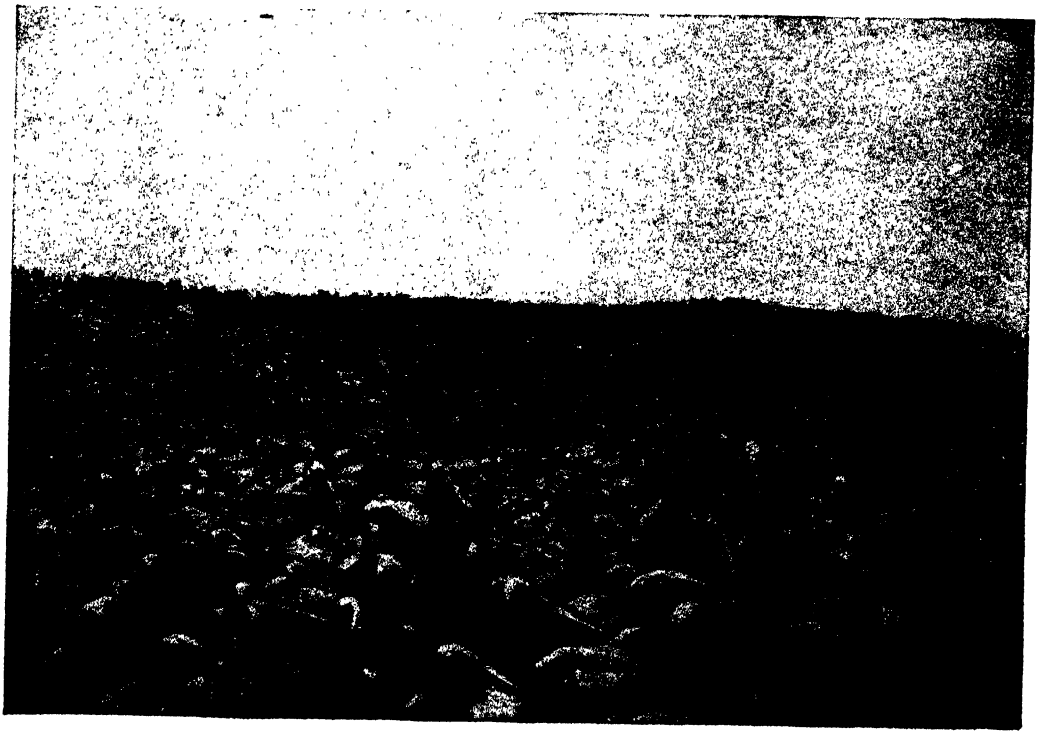
The great field whence the world derives its nitrogenous fertilisers to-day is itself one of the most barren spots on earth. It is confined to some 2,000 miles of the Pacific coast of South America, to the coast itself, and to its innumerable islands. On the islands and headlands is the guano of countless myriads of sea-birds, which have assembled there since days before history to lay their eggs and hatch their young. Both fossil and deposits of more recent origin are here obtained. But on the mainland proper, extending far inland, is the nitrate of soda itself. Of what it truly consists no man can say. There are various theories. One is that the land on which the deposits occur, though now a plateau standing from 4,000 to 5,000 feet above sea-level, was, within a geological yesterday, the original sea-beach, and that the nitrates result from past forms of animal life of which now but the desiccated nitrogenous elements remain. A second theory is that the nitrogen has been isolated from the air by atmospheric electricity and carried slowly to earth. A third is that the nitrates are simply the nitrogenous residua of guano from which the action of the air has removed all other constituents, and that it was deposited where now found, or has been carried by the winds of unnumbered centuries from the adjacent islands.

Where Rain Means Ruin

Be the origin what it may, there lies the substance which keeps the wheatfields of the world productive. Barely a blade of grass grows upon all this vast field. It is a land of mountain and barren plateau, absolutely waterless. Were it otherwise, were heavy mists or rainfall experienced, the world would be brought face to face with general famine, for the nitrate fields would be dissolved! The deposits lie, intermixed with the dust of weathering hills, with sand and pebbles and salt, upon the surface of the land, and deep down in strata varying between 2 feet and 4 feet in thickness.

The precious product is obtained by drilling holes in the ground and exploding dynamite cartridges, which break up rock and soil, and yield a debris which is conveyed to boiler-houses, and there stewed and distilled and strained again and again until impurities are refined away, and 95 per cent. of pure crystals of sodium nitrate remain. This is packed in bags and exported for use the world over, to nourish the fields that grow our corn, to colour the strawberries that are sold for 30s. a pound at Christmas, to give the tomato its ruddy love-apple glow, to enable the horticulturist in sunless England to furnish us with lilies in midwinter, and crop after crop of flowers from the greenhouse a full month before Nature begins to stir the sleeping buds of the outdoor growths.

It is a wonderful, romantic industry, this fertilisation of field and garden by an area which of itself, unwatered and undamped, cannot produce vegetation enough to support a grasshopper. Whence the invaluable nitrates derive none can tell us, but we all know their worth. We have our food and live, because, long ago, when man was not, multitudinous dragons of the slime gorged themselves with creatures of a type now numbered with the rocks of which they form part, and left the indigestible fragments to fossilise into curious shapes resembling marble. Their secret was ground from them by an inquisitive dean, who begged a pendant from a pretty girl's rosy ear, and so set on foot a world-wide search, culminating in the coastal fields of Chili.



On the Guano Islands

On these islands myriads of sea-birds have assembled since days before history to lay their eggs and hatch their young

Dreadnoughts of the Air

The Aerial Branch of Germany's Navy, and How its Cruisers are Built

SITUATED at Friedrichshafen, upon the shores of beautiful Lake Constance, is the birthplace of the Zeppelins. At the beginning of the century a wooden hangar and a few sheds served Count Zeppelin for workshops.

Count Zeppelin

The elderly German Count had practically devoted all the spare moments of his life to the study of "lighter-than-air" flying machines, and had ultimately come to the conclusion that the machine upon which he should strive to obtain success would be rigid. A rigid machine is a framework of wood or metal, divided into various compartments, in which are placed ballonets filled with hydrogen; the whole being protected by a covering of heavier material to maintain the machine's characteristic shape.

With this ideal before him the Count set out upon his researches, and for years he laboured, until, at the advanced age of sixty, he drove his first great Zeppelin into the air.

Its life was, however, a short one, for, struck by a sudden squall when on terra firma, it was hurled against the trees and torn to pieces. Undeterred by this piece of evil fortune the Count commenced to build his second ship on practically similar lines, but it was not until he had made a magnificent trip in his fourth vessel that the German people, realising the extent of the French development in dirigibles, raised a frantic cry, urging the Government to buy the machine.

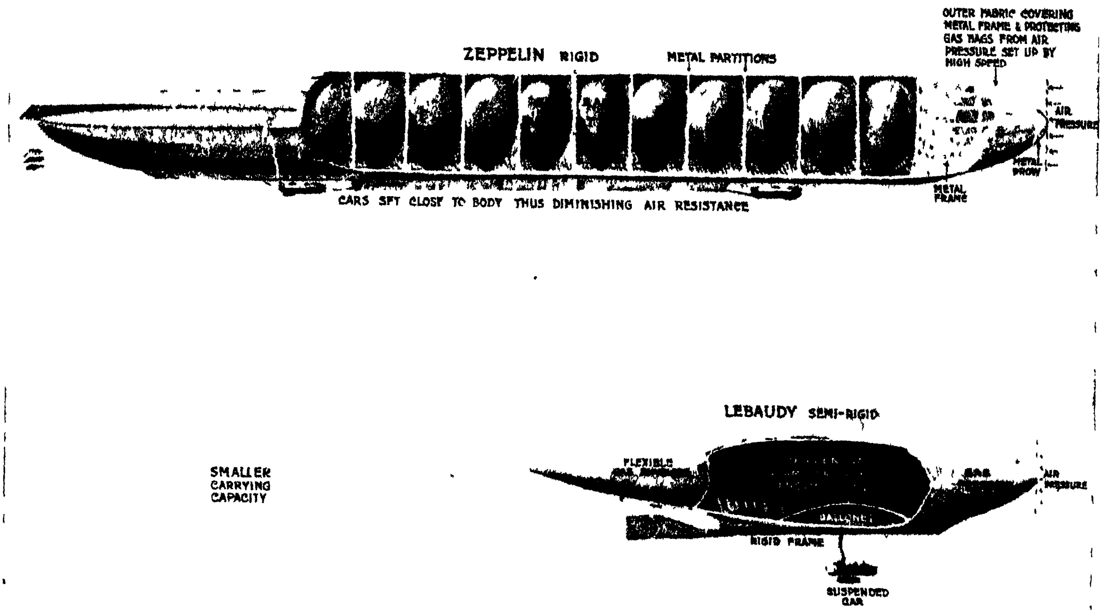
Under heavy pressure, and partly infected by the wave of public enthusiasm, the bargain was struck, and the Count at last rescued from the financial embarrassment under which he had laboured owing to his experiments swallowing practically all his private fortune.

To-day the Friedrichshafen factory, the Potsdam factory and the Schütte-Lanz works (now building Zeppelins), are turning out between them for war purposes one completed Zeppelin every week, and the time occupied in construction has been reduced to three months. There have also been installed, of course, the necessary plants for making hydrogen.

The building of one of these giant vessels is a difficult and intricate piece of work. Firstly, all the material must be strong to stand the severe strain brought to bear upon it by wind pressure; and, secondly, it must be as light as possible. The huge "envelope," or hull, is built up in a framework of aluminium hardened by the introduction of an alloy. From the light steel cap that forms the prow the hull is an intricate mass of aluminium girder work, the whole braced together by miles of taut wiring.

The Ballonets

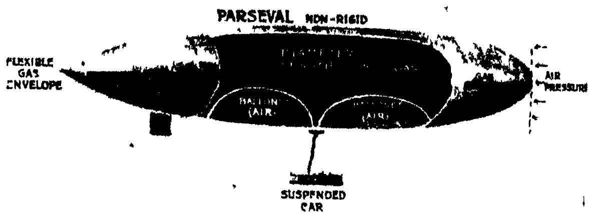
This skeleton is again divided, in the latest machines, into seventeen compartments, into which at a later date are introduced the seventeen ballonets, which consist of gas-proof material as light as possible, and which, when filled with hydrogen, give the machine its lifting power. Next, over the whole framework of the ship, is drawn a stouter fabric consisting of a mixture of cotton and rubber, which is not necessarily gas tight, but is treated with a waterproof dope to make it weatherproof. The whole hull is 165 metres in length. During this time the work of constructing the gondolas, or cars of the machine, has


ZEPPELIN RIGID
METAL PARTITIONS
OUTER FABRIC COVERING METAL FRAME & PROTECTING GAS BAGS FROM AIR PRESSURE SET UP BY HIGH SPEED
AIR PRESSURE
METAL PROW
METAL FRAME
CARS SET CLOSE TO BODY THUS DIMINISHING AIR RESISTANCE
SMALLER CARRYING CAPACITY
LEBAUDY SEMI-RIGID
FLEXIBLE
GAS
AIR PRESSURE
BALLONET
RIGID FRAME
SUSPENDED CAR

been progressing in another part of the factory. These are suspended below the envelope, and in all the Zeppelins, with the exception of the latest type, two are carried, one at each end of the framework, and connected by a light, canvas-covered and V-shaped gangway.

These gondolas are marvels of light yet strong metal work, and are so formed that they float should the dirigible alight on water. Round the sides run a padded bench, roughly 24 inches from the floor, upon which the look-outs can stand and peer over the sides.

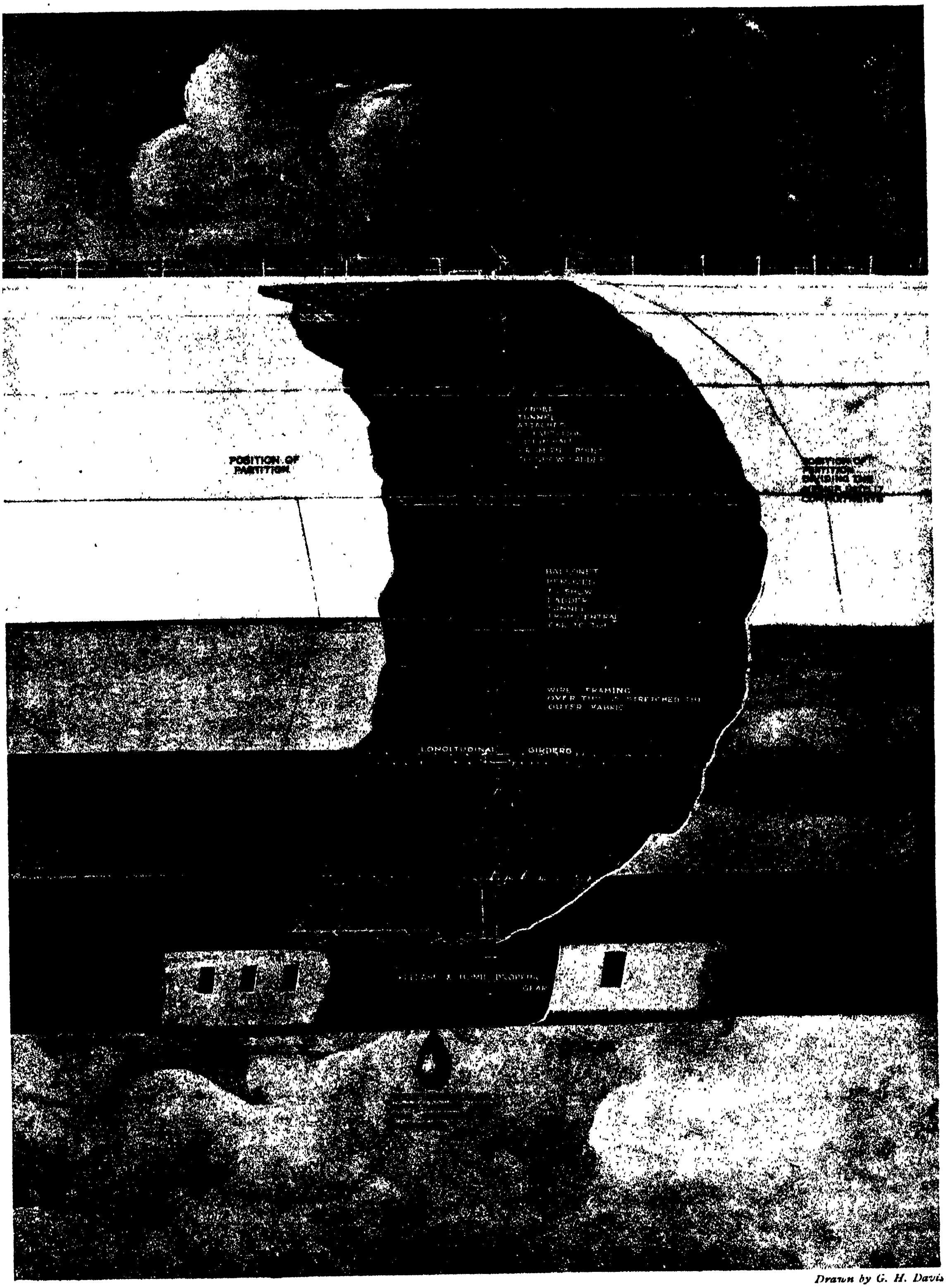
In the centre of each car are placed the two Maibach petrol motors, each developing 200 h.p., and coupled together. From each side passes out the large shaft that goes up to the propeller, which is slung out on steel and aluminium bracing, attached to either side of the framing of the envelope. Four of



Drawn by G H Davis

Three Types of Dirigible in Section

The *Zeppelin*, with its rigid framework of aluminium protecting its separate ballonets, and its great length, has little head resistance in comparison with its size, and slips through the air with little friction. The semi-rigid type has a stiffening keel to keep the balloon in shape. The non-rigid feels the effect of air pressure (tending to force the bag out of shape, with consequent loss of gas) most of all



Drawn by G. H. Davis

Amidships Section of a Zeppelin

The fabric has been cut away to show the delicate tracery of steel and aluminium. A ladder passes right through the centre of the vessel from the central car to the top of the envelope. This top is strengthened by steel framing, and upon it is mounted a light quick-firing gun to defend the ship against aeroplane attack from above. The gun platform is placed over one of the seventeen partitions of the Zeppelin's envelope

these motors are fitted, each revolving a single four-bladed propeller, which is driven off each shaft by bevel-gearing, and gives the machine a speed in excess of 60 miles an hour. The engines are cooled by a large box radiator fixed over the side of the gondola, and midway between the car and the envelope, so that it is right in the air currents caused by the cruiser's passage. This causes a continuous circulation of cold water round the cylinder jackets, which keep the motors quite cool even after a thirty-six hour trip.

Aeronautical Instruments

Forward again of this is the position of the steersman, who is protected in all the later vessels by a transparent shield, and who steers the gigantic machine by a wheel not unlike those employed at sea. To the steersman's left are the stabilising controls, and before his eyes the neat aero compass, altitude gauges, and other necessary aeronautical instruments. In the second car are another set of engines, and between the two are to be found the living quarters of the crew.

This space perhaps impresses the visitor more than any other portion of the machine; it is so compact in every way. Here are to be found the neat wireless installation, the sleeping quarters of those of the crew off duty, and also the electrical cooking devices. In the "roof" of this aerial haven is a tunnel, that goes right up through the centre of the vast envelope to the top of the fabric, where may be found a narrow gangway. In all the modern cruisers the framework has been strengthened, and a quick-firing gun mounted. This weapon is really nothing more than an automatic rifle of the Colt pattern, but is capable of firing bullets at the rate of a Maxim gun at any bomb-dropping aeroplane that came too near the top of the dirigible.

At the stern of the giant framework are horizontal rudders for controlling the up and down flight, and the vertical rudder that governs the direction of the craft to right or left.

Next to the dirigibles themselves the system of handling and housing these gigantic yet fragile structures is one of the wonders of modern Germany. The 700 men that are employed work with perfect unison and trained understanding, and the vast gas bag is drawn from its shed and put back with extraordinary dispatch. In some cases a rail is provided, to which is fastened the bottom of the gondolas, and the machine is housed in this way. In other places sheds are being constructed that revolve, so that at whatever point the Zeppelin comes to earth, the whole structure —which is built to withstand the terrific wind pressure it has to meet, and is as big as Olympia, London—is turned with the ease of a gun turret until the mouth gapes open ready to receive the resting airship.

In one other instance, at least, the whole shed will be let into a pit in the ground, and will rise bodily, by means of hydraulic power, to receive the Zeppelin. When the air cruiser is housed safely inside, the shed will sink into its pit again, with its roof forming a steel protection against the bombs of any of the enemy's aircraft.

Increasing Size

The size of the Zeppelin is gradually increasing, and so is the engine power, and it has been confidently predicted in Germany that the future airship will be six times the size of the modern Zeppelin, with a speed of perhaps 100 miles per hour! To-day the present Zeppelin can lift *one ton* of explosive; no doubt, as time goes on, air cruisers will be devised capable of carrying much greater loads of destructive missiles.

In conclusion, it may be mentioned that the Great War has proved that the flimsiness of its construction, and its great liability to be affected by adverse weather conditions, are the great drawbacks of the Zeppelin, which, as a fighting machine, has not come up to German expectations.

A German Air-Dreadnought (the "Z III") Battling with a Thunderstorm

The size of the Zeppelin is gradually increasing, and it has been confidently predicted in Germany that the airship of the future will be six times the size of those now in use. Even at present these great airships can lift or drop one ton weight without disturbing their stability

The Exceptions

Sea Creatures which Avoid the Law of Violent Death that Rules Most of the Brute Creation

By FRANK T. BULLEN

Author of "The Cruise of the Cachalot," &c.

NO careful reader of natural history can have failed to notice that among all the lower animals in a state of nature a universal law prevails, a law for which no succinct title exists, but which we may call the law of violent death. In other words, all animals from the lordly elephant down to the ridiculous mouse, have their enemies (apart from man—the universal enemy) to whom sooner or later they fall victims. Now, this law varies in its application according to the rank of the creature; for instance, the elephant, rhinoceros, or hippopotamus are far less liable to fall victims to their enemies than quick-breeding animals lower down the scale, but these exceptions are very rare.

Photo P. Stammwitz

The Monarch of the Seas

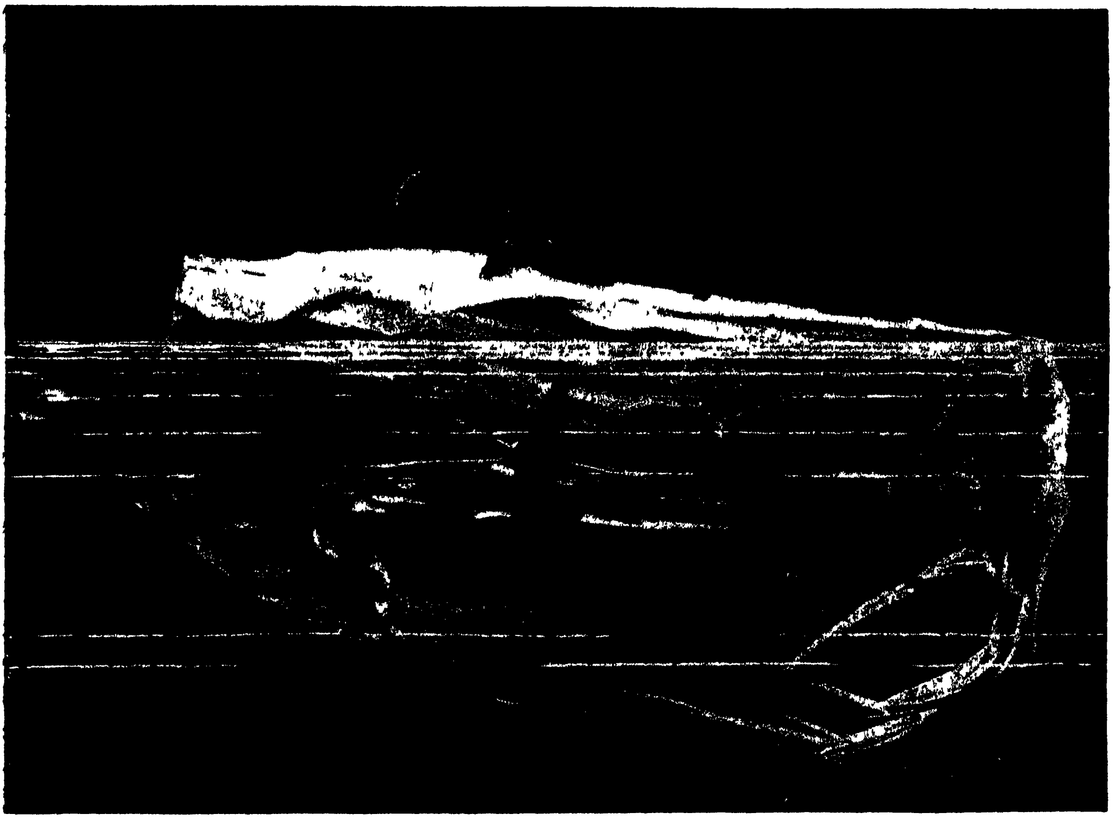
The huge balloon-like structure on the right is the dead whale's inflated tongue

When, however, we come to the mysterious ocean, where there appears to be a law of absolute interdependence, where "eat and be eaten" seems the universal law, far more rigidly observed than on land, we find several cases of exceptions much completer than is the case on shore. For none of the land animals or birds are immune; some enemy is ever on the watch for their hours of weakness or lack of watchfulness, and then comes the swift end. This is not the case with the sea denizens, of which I wish to speak here. Of these exceptional creatures it is strictly proper to speak as having, once they become adult (prior to that no creature is immune), no enemy at all but man, and he usually only from sheer wantonness.

First among these exceptions I would take the sperm whale. Alone of all the cetacea, he roams the sea secure from attack by any animal. All other of the sea folk but he, even to the gigantic rorqual, may and frequently do fall victims to the sudden furious attack of natural enemies. Cases have sometimes been observed where such incongruous allies agreeing only for a common end, as whales, sharks and sword-fish, have together attacked the vast sluggish mass of the *Mysticetus*, and have invariably succeeded in slaying their immense foe. Nor has the subsequent division of the booty caused these strange allies to quarrel; indeed, that could hardly be so, seeing what a great multitude of the sea-folk will flock to the banquet.

But no one has ever seen or heard of

a sperm whale being thus attacked and overcome. He is too terrible, too fully armed, with lethal flukes at one end and his gigantic tooth-filled jaw at the other, to become an easy prey even if he were as pusillanimous as a "right" whale. That, however is, to those who know him, unthinkable; for allied to his great defensive powers he has a gallant spirit and will to use them. So that he may truly be said to be the only animal who need fear no foe. How long he thus remains to roam his watery realm between the temperate zones no one knows, nor how and where the universal conqueror meets him at the long last. There are secrets of the ocean that are hidden from us. We can only say that, except when some terrible gale has caught a school too near a shelving shore and hurled them thereon, or when, after a long fight, one has escaped mortally wounded from a whaler's attack, dead bodies of sperm whales have never been seen. And this is the more singular since they are the only whales inhabiting temperate and tropical seas which invariably float when they are dead.



Killer Whale Attempting to Roll Men off a Piece of Floe

Unlike other whales, which live on the minute forms of sea life, the Antarctic Killers are fierce carnivores. In "The Heart of the Antarctic," Sir Ernest Shackleton describes how a school of killers endeavoured to capture members of his party who were adrift on a floe, in the manner shown above

Another of the favoured ones is the turtle in all his varieties. Enemies he may have in plenty, as have the eggs and immature young, but none that can do him any harm. Safely ensconced within that armour of proof, the turtle lives on, to a prodigious age, the length of which, as in the case of the whale, is utterly unknown to us. He dies of senile decay in some remote sea grotto, to become the food of myriads of tiny sea-scavengers who are ever at hand to perform their appointed task of keeping the sea sweet and free from decaying matter. The case of the turtle is more marvellous than that of the whale, because of the amazing fecundity of the former, and the way in which both eggs and young are devoured by birds and all fish. I once assisted to "turn" a turtle before laying. Its eggs, piled upon the lower shell, were as much as two strong men could lift—well over a thousand in number. Only two or three per thousand can survive, but they, once they have passed the dangerous age, are amongst the little band of immune sea creatures who have no efficient enemies, excepting, always, man.

Photo W. S. Berridge, F.Z.S.

Frigate Bird

A pirate of the seas. It allows other birds to catch fish of different kinds and then robs them of their prey

As I am only taking a very few of the sea-people for my examples, and only those I know personally, I would like next to mention the frigate bird. This is one of the paradoxes of the sea. Essentially a sea-bird, it cannot alight upon the sea for it has no webs to its feet, and it is consequently driven to sheer piracy for sufficient food. It hovers at an immense height over the sea near the shore it nests upon, never flying far seaward, and thus it waits for the home-coming gannets or boobies bringing fish to their young. Like a thunderbolt it descends upon them, and when they, naturally, drop their booty, the graceful thief swoops upon it, catching it before it reaches the sea, and soars off devouring it. Occasionally a flying-fish, darting through the air, is seized and devoured, but the main source of supply is as I have indicated. Then, when old age creeps upon the pirate, and the mighty pinions grow stiff, it remains on its perch and starves to death, for it has no enemies to give it speedy and merciful release.

The splendid albatross, most wonderful and beautiful of all sea-birds, is also immune, but where or how it yields to the universal command I do not know. Its power of flight is only equalled by its enormous appetite—I have often seen it gorge itself with blubber till it could not fly; and then, after a few minutes' envious grumbling, disgorge in order to rejoin the banqueters.

Its home is the ocean, but when the breeding season comes, it hies to some barren, lonely rock, far from the haunts of men and unfrequented by other species of birds.

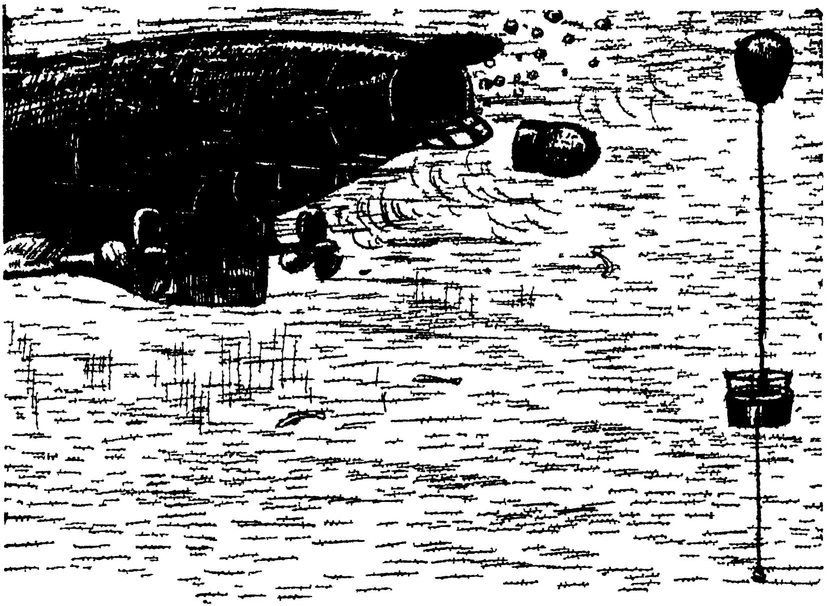
There it broods over solitary eggs, and there, I should imagine, it retires to die when it feels death coming. But I have never known anyone who has seen a dead albatross, unless it had been killed by the hand of man.

Submarine Mines and their Work

Concerning the Deadly Death-dealers of Modern Naval Warfare—How they are Combated by Intrepid Trawlers

EVERY class of naval man, no matter what flag his vessel may fly, looks with something akin to disgust upon the submarine mine. The lesson of the last great naval war between Russia and Japan went to prove very conclusively that the submarine mine was a truly dreadful death-dealer, for during that great Far Eastern war the Russians lost the flagship *Petropavlosk*, and the Japanese the great battleship *Hatsuse*, through coming in contact with mines.

To-day the mine is still looked upon as a great defensive force, and is used very extensively in defending war ports. Wet gun-cotton is the explosive now almost universally employed; it has the advantage of being slow to explode, and can be moved and manipulated without very much danger to the submarine miners. By a new process the gun-cotton is now compressed into solid blocks of any desired size or shape, and these are placed in the iron cases. To-day the cylindrical form of case is usually employed. This is made of wrought iron riveted together, and is nothing more nor less than a large ball to which chains are attached so that the mine can be moored in the desired position. The spherical case has been adopted as the result of exhaustive experiments, by which it was found that this form is most capable of withstanding external pressure, and offers the least resistance to tidal currents; it is, therefore, the least liable to be affected by an enemy's attempts at countermining.



Drawn by G H Davis

German Submarine Launching Explosive Mines

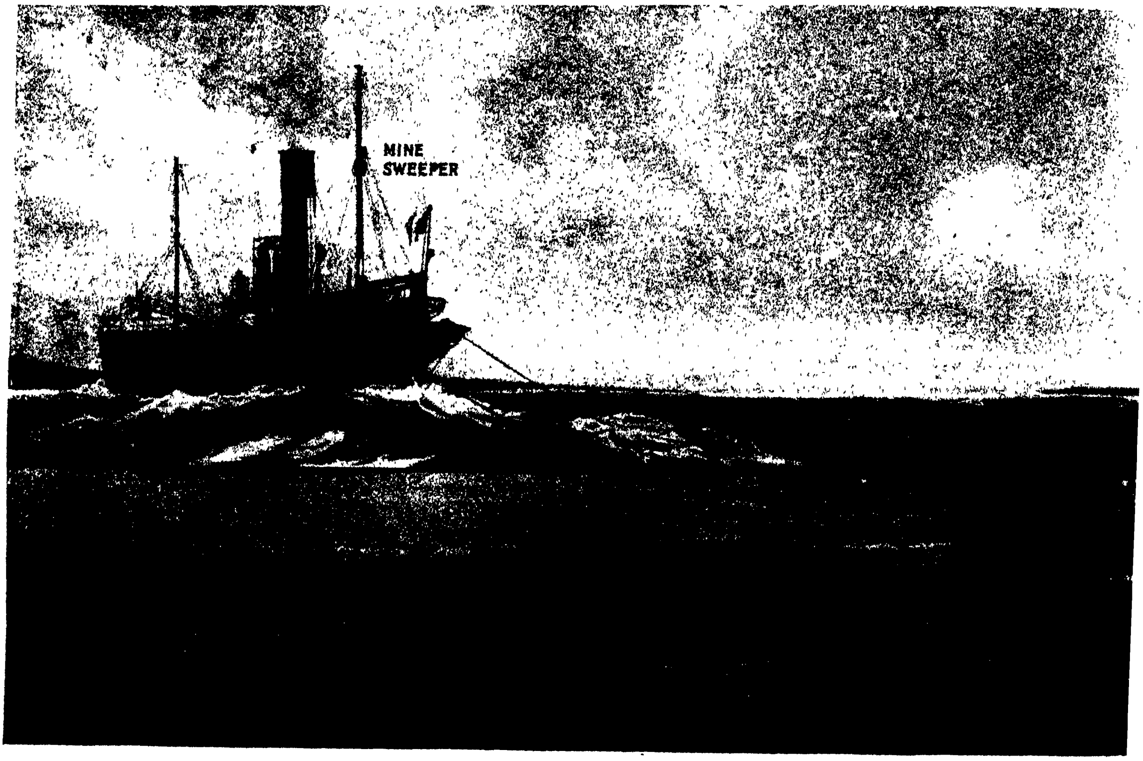
The type of mine now generally employed by belligerents is made to contain a 100-pound charge, if used as a buoyant mine; if used as a ground mine, a cement lining is formed inside the iron shell, and 500 pounds or more of explosive enclosed.

The type is excellent for harbour defence, and if used as a ground mine, it can be placed under the fairway of the ships, and is connected by electric cable with a station ashore. By this means a channel right through the centre of the mine field is found, so that friendly vessels, knowing the course, can come or go without danger, but should a hostile ship attempt to rush in, then these sinister globes nestling along the sea bottom, can be instantly fired from the land.

The shore station is usually to be found within the defensive works of the port, and is a stoutly-built little cabin, in which is a wonderful array of gleaming switches as well as a number of instruments (of a nature only known to the operators and to the superior authorities) which can tell to a nicety when a hostile vessel is directly over the mine.

With the 100-pound charge a cylinder can be moored as a buoyant mine on the sides of the fairway. Such mines are usually moored about 12 feet below the surface, and kept in position by a heavy iron sinker resting on the bed of the harbour. The latter is connected to the floating mine by a stout chain cable. The mine can either be fired from the shore, in exactly the same way as the ground mine, or—when a detonator of fulminate of mercury, in connection with a small priming charge of dry gun-cotton is used to explode the mine—by contact with a ship.

There is another type of mine, which, for want of a better name, is usually called the floating drift mine; this came into being at the time of the Russo-Japanese war. This type is simply a mine, minus any form of sinker, that is dropped overboard, either from specially-fitted destroyers or from ordinary steamers altered to suit the work. The Japanese had the famous *Koryo Maru*, and the Russians the equally well-known *Yenesi*. These ships had cut-away sterns, so that, as the vessel steamed at sea, the mines would be dropped in the enemy's area, and allowed to float, form-



Naval Mine-sweepers Drawing Sweepi

ing a dreadful menace not only to the belligerent ships but also to the neutral trading craft in the vicinity.

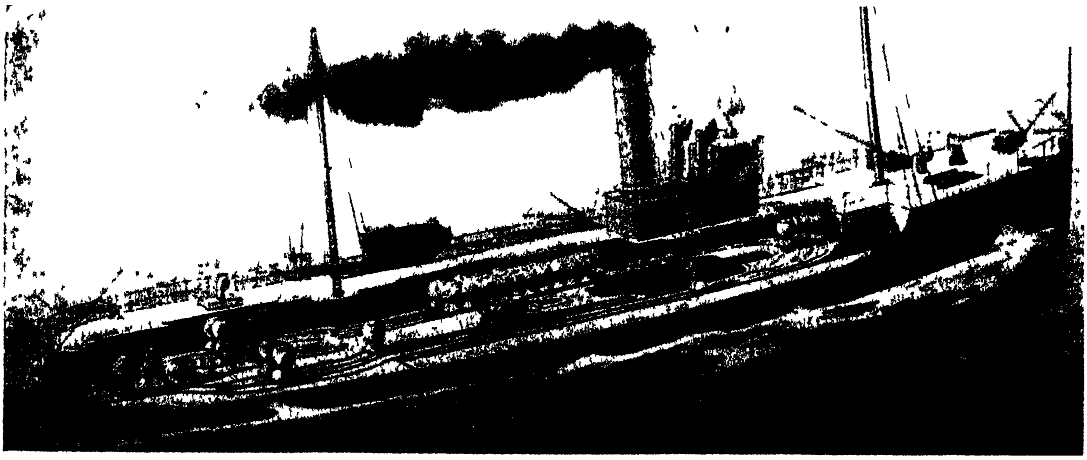
Drawn by C. H. Davis

Wire Across an Enemy's Mine Field

Notwithstanding the fact that most humane opinion is against the employment of these wonderful yet awful instruments of death, the drifting mine has been very extensively employed by Germany during the Great War. Now that the submarine has advanced so rapidly in power, size, and effectiveness, however, these terrible little under-water battle craft may by international agreement totally displace the drift mine, and, to a certain extent, the floating mine field, in the not far distant future. Whereas the drift mine is equally a menace to friend and foe, the submarine, controlled by highly-trained human brains, can do its deadly work against hostile craft without necessarily endangering neutral shipping.

The nations of the world have to be prepared for every eventuality; from the somewhat crude methods of the Japanese and Russians of a decade ago, all the great navies of the world have now their mine-laying ships. These vessels, in some cases, have been specially constructed for the work, and inside their steel skins are miniature workshops for attending to the delicate mechanism of the mine; further, there are magazines for the compressed gun-cotton and special places for the storage of the cases. The Allied Navies have, at the time of writing, many such vessels, mostly old cruisers that have been altered and adapted to suit their new duties. These vessels, the intrepid crews of which have done yeoman service during the Great War, have had a certain portion of their stern cut away, and, under the raised poop, lines or rails have been built into the ship extending right out clear of the hull, and passing through the hole cut in the stern. To lay out a mine field, these vessels steam leisurely ahead and the mines are rolled down the rails and dumped into the sea clear of the hull, rudder, and propellers. The sketch on page 959 shows a German invention for the launching of explosive mines from specially designed under-water craft.

But now we must look upon the other side of the picture—i.e. what is being done to combat the terror of the mine? Here we come upon perhaps the strangest vessels to be found in our fleet. They are nothing more than the trawlers that are so familiar on the North Sea. These trawlers were purchased by the Government a few years ago, painted the familiar navy grey, and specially adapted, not for the trawling of the cod but for a more difficult and dangerous rôle—the creeping or trawling for submarine mines! When Germany embarked upon her "blockade" of Britain she reckoned without the preventive force of seasoned fishermen whose activities checkmated her efforts at every turn.



Drawn by Albert Sebille

Sectional View of the French Mine-layer "Cerberus"

Showing how her 120 mines are stored and launched through a special port-hole in the stern

At Grimsby and Hull, certain other trawlers that were ordinarily employed in their regular trade of fishing could, on the outbreak of war, be used for "mine-creeping," and, accordingly, their owners were subsidised by the Admiralty. Their crews were given a retaining fee, and, being duly sworn to secrecy, became practically Royal Naval Reserve men.

The method employed is simple and ingenious. Assuming that a certain mine field has to be "cleared," two or more of these "creepers" steal outside the mine area, each towing well astern, sunk to the sea bottom, a heavy iron sinker, or, to employ its correct name, a "kite." This large casting is V-shaped, and attached to it is an iron pulley or block; through this runs the "sweeping-wire," which is attached to a hauling drum on the deck of the trawler, and passes over the stern, and then, going through the block of the kite, stretches away across the sea bottom to the second kite, trailing behind the sister "creeper" on the opposite side of the mine field. The necessary cable being swung out, the two vessels creep ahead in direct line. Well astern, at the bottom of the sea, trails the sweeping-wire, which, passing slowly along, naturally catches the sinkers and chain of the mines. Thus these dangerous fish are swept together; even if one or more do explode, there is no danger to the ship employed, as it is well out of the way. When all the mines are drawn together, a large charge is placed in position, and the whole lot destroyed.

Photo by permission of the Queensland Government

The Last of the Native Huts on Murray Island

Nature as Man's Master

How, not Conquest, but Adaptation, Enables Mankind to Hold the World in Fee

MAN as lord of creation, is, after all, but the henchman of Nature. He has not mastered Nature.

For example, how does that dreadful crime—as it seems to us—infanticide arise ? In the case of many primitive peoples, from stern necessity.

Tribes such as inhabit the darkened heart of Africa, the lovely but limited islands of the Pacific and other regions, cannot conquer new territories. Nature seems to set them their bounds which they may not pass, and the time comes when to the native it seems that the dictates of Nature must be complied with; he flees from starvation to the remedy which Aristotle approved—infanticide. The power of the human race to multiply is necessarily restricted by the limits of food supply.

With less of humanity and the qualities which civilisation connotes, even civilised races might possibly, ere this, have been driven to infanticide, as happens among "lesser tribes without the law" whom civilisation counts not of her children. In place of infanticide they have taken to sending out and peopling the earth.

Classical Greece, with the fairest climate and the most limited of home territories, became the educator of Europe while slaughtering her children as blithely as—until half a century ago—the South Sea Islanders slew theirs. Every nation did the same thing—the Norse, the peoples of India, the Chinese (as they do to this day), the Poles, the Arabs. Different pleas served different nations, but at the back of all there was the Arabian idea that the multiplicity of mouths would bring the sire to starvation in a land unfitted by

Photo by permission of the Queensland Government

A Native Village on Murray Island

The strict limits which geographic conditions set upon possible expansion fundamentally affect the manners and customs of island populations. Polyandry and infanticide are the direct result of the islanders' environment

stern Nature to support more than the select few.

Of course, this interpretation of Nature's dictum was all wrong, and is wrong to-day, but where civilisation and its teaching have failed to point another way out of the difficulty, wild men and women buy their own existence of Nature at the cost of the lives of their children. It is their way of adapting themselves to environment, of making demand accord with available food supply and residential facilities.

The lot of the Murray Islanders is, in savage miniature, that of civilisation. The Murray Islanders' ancient remedies for restricted territory are modified by the presence of missionaries, but they cannot master their environment sufficiently to make elastic that which is inelastic. They are slaves of Nature, confined within a ring of sea. This inability of man to master his surroundings has in the past sent nations reeling across the world. One such began in waves beating upon the Great Wall of China, and ended by thrusting Alaric and his hordes upon the gates of Rome. Another, almost of our own day, flung a section of the Zulu people into a sanguinary crucible and brought out—the Matabele nation. All such movements are traceable to the natural, hard, cruel, masterful causes of Nature.

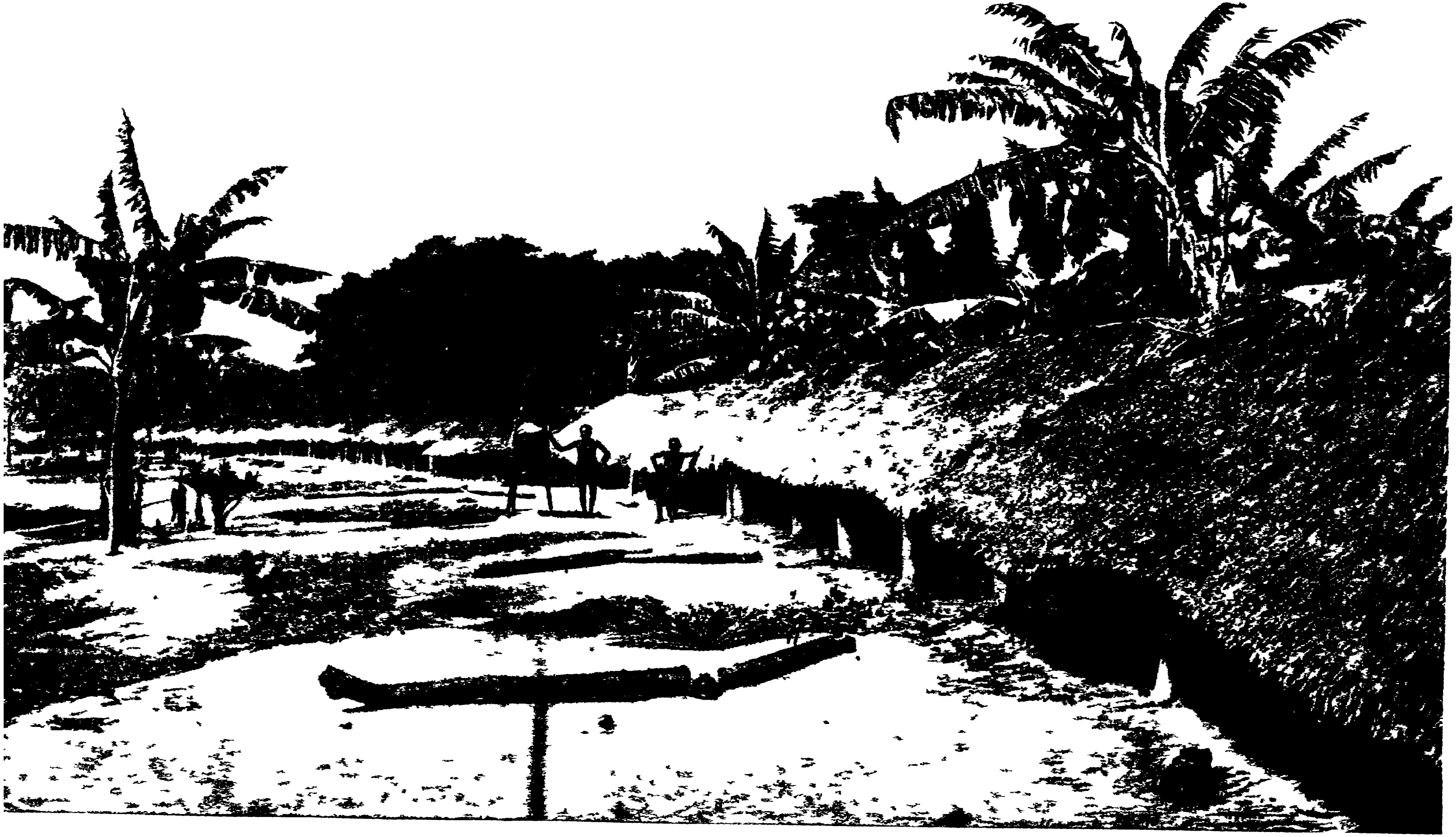
But the poor Murray Islanders, with their specialised dwellings in a specialised territory, cannot break out; inexorable cause and effect have seen to that. They have their counterpart in civilisation. The people of New York and other cities of the skyscrapers are Murray Islanders of the *n*th power. They had no where to lay broader foundations for their buildings, so they built up into the sky.

The Japanese, masters of all the crafts, are ruled entirely by natural laws in the terms upon which they prosecute their civic life. They dwell upon a nest of volcanoes and upon lines of earth-cleavage,

Photo by permission of the Queensland Government

Natives Tree-climbing at Kenilworth, N.C.R.

Natives of one district can climb trees which men from others could not attempt



Rev. John Weeks

Polygamy Terrace, Monsembie, Upper Congo

The long terrace here shown is the home of one polygamous chief, who houses one wife in each of the many "compartments" of his abode. It is a remarkable fact that polygamous marriages seldom mean large families, a chief may have a dozen wives, but only three children

and they build, not to please themselves, but in deference to natural conditions, houses which will sit down in time of trembles and not crush their owners. The architects and engineers of San Francisco, warned by their earthquake of the other year, are following out the same idea, but executed upon different lines. We cannot master the earthquake, we cannot quench the volcano; we can but build in such manner as to adapt ourselves to the known conditions of peril.

Man is the farthest-ranging of all the animate family, but he conquers no place; he adapts himself to the local conditions, or dies. Vilhajalmar Stefansson, the Arctic explorer, flourished and fattened in the very territory where Franklin and his six-score men starved and perished, all of them, even those who had recourse to cannibalism. That one man's meat is another man's poison holds good in more than the limited sense of the axiom. Nature offers life upon her own terms. An unarmed white man would perish in the forests of Burma, but families dwell there in relative ease by fitting themselves to circumstances. They have returned to the point from which our ancestors advanced; they have their homes in the trees. They have but copied from the apes. They can climb, and having climbed, can build, where a white man cannot readily follow. And they live safe from the wild beasts of the forest.

All the curious customs of savage life arise, in the main, from compliance with Nature's unbending laws. It is a wonderful thing that savages should have learned that Nature abhors inbreeding, and should practise exogamy, the capture of wives from other tribes. That is part, however, of a greater law, the law that the fittest shall survive to reproduce his kind. The best fighter, the best hunter, the most intelligent, will succeed at the cost of the less efficient, and it is for the best man that Nature is always looking. Nature demands that certain of the Burmese shall be good arboreal builders, and the best builder will have the largest family.

In Queensland some tribes are more simian in life than others; they can scale gigantic trees, smooth-trunked and towering, the very look of whose summit would cause vertigo in an ordinary man. The best of these good climbers will get the choice of brides. He may have one wife; by climbing better and prospering he may have half a dozen wives, and presumably he will hand on his soaring tendencies to his offspring who, in time, will outsoar his sire.

Photo R H Kirkland

Boboka Chief with Wives and Children

Polygamy has its origin in quite natural causes, which there is no space here to discuss, however. It is general throughout Africa to-day, where, indefensible as it appears to us, it is, at the outset of a man's career, at any rate, an incentive to industry and always to valour. Since like tends to succeed to like, then, with industrious and valorous sons following industrious and valorous fathers, there should be, on the whole, an uplifting tendency even among the unclad polygamists of the Congo.

Nature as an Architect

The Lily-leaf Model of the Crystal Palace

By N. F. WATSON

OF the millions of people who, from the time of its erection, have visited the Crystal Palace, few know the origin of the building. That the entire structure once stood in Hyde Park, London, and housed the treasures of the Great Exhibition, and was removed thence to crown the slopes of Sydenham, is common knowledge; but who remembers the romantic story of the conception of the plan upon which the building first arose? Probably none but a botanist with a gift for mechanics would identify the wonderful scheme of steel beams and ties as having been copied from the leaf of a plant. Such, in fact, is the true story of the genesis of the Crystal Palace.

Sir Joseph Paxton

Sir Joseph Paxton, the designer of the Palace, had been a poor youth, working as a jobbing gardener, and had found his way to Kew Gardens, whence he was transferred, by the then Duke of Devonshire, to Chatsworth, with whose marvellous scheme of rock gardens, fountains and greenhouses his name is for all time associated. Now, during his experience at Kew, Paxton had seen and studied the colossal Victoria Regia lily, which flourishes incredibly in one of the great tropical houses of that wonderful Imperial seed-bed. The Victoria Regia is a wild growth of the Amazon and other South American rivers. Its gigantic leaves, five, six, and more feet in diameter, and enormously bulky, float light as feathers on the water. Their buoyancy arises from the unique construction of the underside. Here runs an extraordinary system of spike-armed nervures and thick veins, raised in bold relief from the structure of the leaf proper.

Natural Wickerwork

Unfortunately, the ordinary visitor to Kew does not, as a rule, see the underside of this unparalleled leaf. On special occasions a couple of the attendants, divesting themselves of clothing, pop into the great tank, and, thrusting a wide board beneath the leaf, turn it over to expose the mysterious nether half. The appearance suggests a natural wickerwork. At first sight there seems a casual riot of upstanding veins and nervures, but careful examination reveals the most beautiful plan and system whereby, from the main horizontal "beams" of the leaf, lesser supports radiate in all directions upon what, if made by man, we should term a scientific scheme. By this means every part of the ponderous leaf is adequately supported, and the whole floats light as air upon the surface of the water, and has so much buoyancy in reserve that a child of nine or ten can be supported upon any full-grown leaf.

It was upon this system of nervures and lesser veins that Paxton modelled the Crystal Palace. When the Great Exhibition was planned, the first scheme was to erect a colossal building of bricks and mortar at a huge cost. Paxton, whiling away the time that followed the close of a railway meeting at which he was present, and the arrival of his train, drew out a rough sketch of a building with a framework of steel, designed as the Victoria Regia lily is designed. As soon as he had got the idea on paper he saw that it was good. He worked all night at a fuller drawing, and next day showed it to Robert Stephenson, son of the inventor of the locomotive. Stephenson realised its immense importance, and saw that there was an absolute revolution in architecture, a scheme such as had never before been dreamed of by mortal man.

Photo S L Bastin

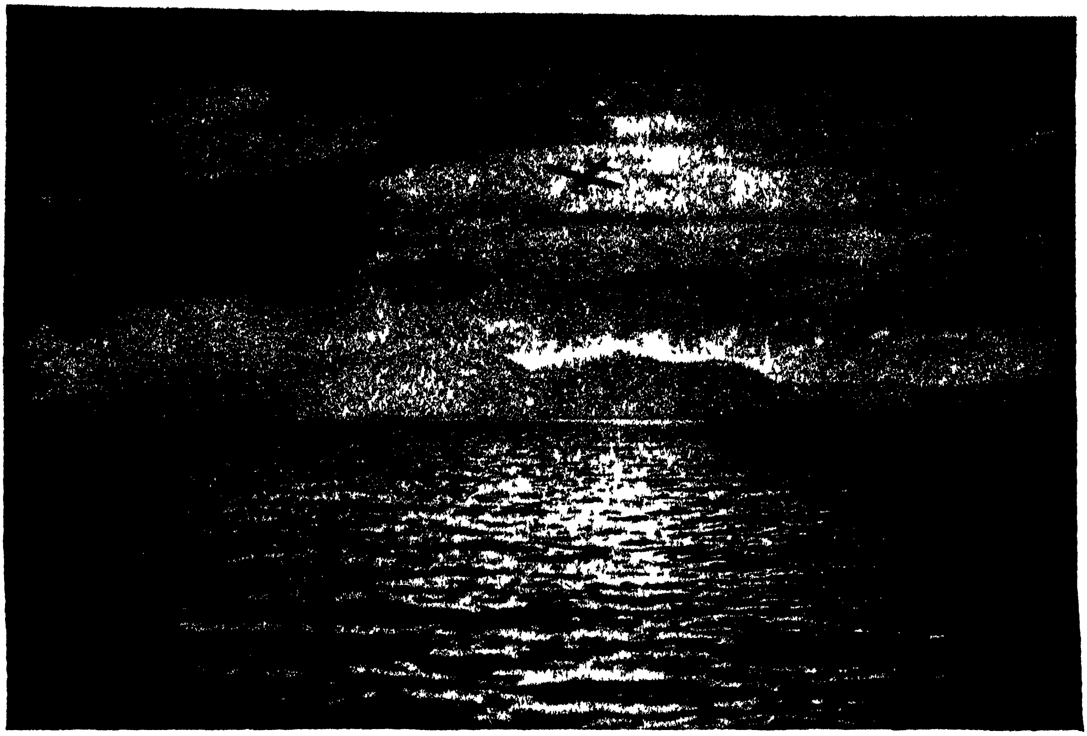
Victoria Regia, the Lily-leaf Model of the Crystal Palace

Although the Royal Commission having the matter in hand had pledged themselves to a brick and mortar building, they were so impressed by the novelty and manifest advantages of Paxton's design, that they adopted it, and the Crystal Palace was built. It marked the most startling advance in architecture since classic days. Scores of other buildings and domes of innumerable railway stations have been modelled upon this pioneer. They all derive, however, from the king of water lilies. In South America the natives, who garner the great seeds of the Victoria Regia and use them as a flour, call the plant the Water Maize. The very seeds of the plant have been exhibited before now in the Crystal Palace, and the lily itself has grown within its limits. But who has realised, on seeing the great plant growing in the Palace, that the latter itself is but the vertical reproduction in steel and iron, filled in with glass, of the lily in the pond ?

Photograph taken from a biplane by M. Jean Voisin

Mediæval Mont Saint-Michel Viewed from an Aeroplane

When the factor of safety has been introduced the air route will provide the most luxurious and delightful of all forms of travel. The aeroplane will be the vehicle *par excellence* of sightseers



Travel de luxe—Smooth, Vibrationless, and Restful to the Nerves

When the World Flies

An Airman's Prophecy Concerning the Dawning Era of the Airway

By CLAUDE GRAHAME-WHITE

USING the cable and wireless telegraphy, men now flash their thoughts and wishes from place to place at lightning speed, defying distance and time. But they themselves, in journeying here and there, must travel still by train and steamship, which, when long distances are undertaken, appear tediously slow.

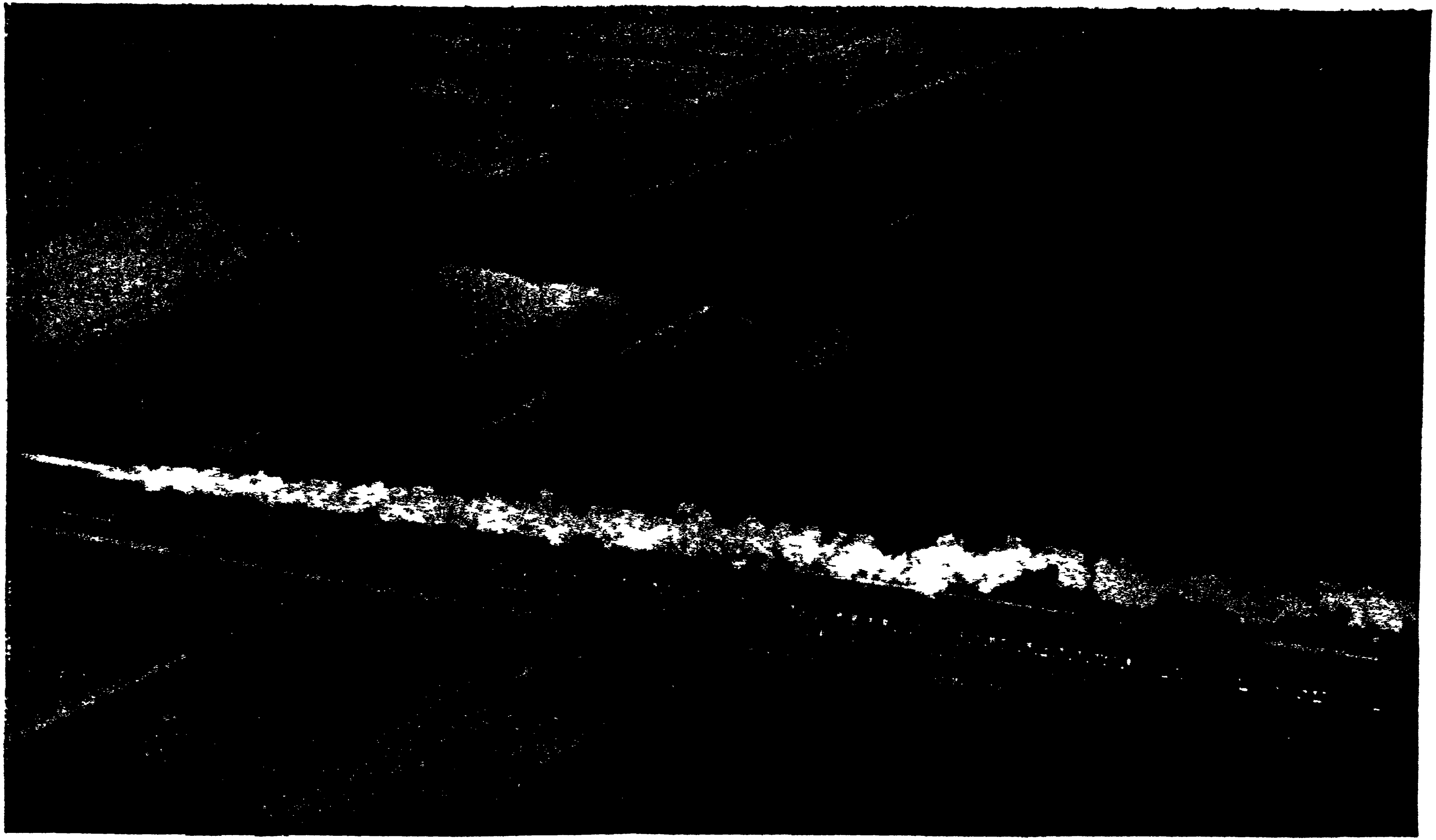
Everywhere, on every hand, the demand is that travel should be speeded up; and yet, both by land and sea, the pace of transit is nearing its limit. It is difficult, for instance, to save even a minute on the time-schedule of an express train; while a vast expense is entailed in adding even a knot to the speed of ocean-going liners. But now dawns the era of the airway—destined to meet the world's wish for this saving of time, which spells saving of money.

Daily—although this fact is scarcely realised—the volume of air-traffic increases; and every day, too, the handling of aeroplanes is rendered safer. In the early stages of aviation, machines were frail and easily broken; but now metal enters into their construction, and they have a factor of safety many times greater than any sudden strain they may incur in flight. The growing skill of airmen, too, is now making itself felt, and long aerial journeys from city to city are undertaken without hesitation or fear of mishap. Men are flying

Photo C I Fa

A Midget and a Mammoth of the Air

This photograph shows a huge German airship blown out of its course and compelled to descend in French territory. The little French aeroplane hovering overhead seems a midget by comparison. It is a matter of controversy whether the airship or the aeroplane is likely ultimately to prove of greater value in the service of man



The Offenburg-Freiburg Express "Shadowed" by the Zeppelin Airship "Schwaben"

This extraordinary photograph was actually taken from the German airship *Schwaben* while manœuvring over and racing with an express train. The dark shape is the airship's shadow cast on the fields over which it was passing in winds, also, which would have been reckoned impossibly dangerous a year or so ago.

Along the great highway of the air, which is the ideal medium for speed, will pass the fast traffic of the future. Even now men fly at 100 miles an hour and more in racing monoplanes, and this is but a beginning. With perfected aircraft a pace of 150 or even 200 miles an hour should be possible.

Photo News Illustrations Co

A Luxurious Aerial Two-seater

Runabouts of this description, which already cleave the clouds, will bear the same relation to the mammoth passenger-carrying aeroplanes of the future as small boats do to ocean liners

In the days of the commercial aeroplane, flying will be regulated and controlled. Already steps are being taken to this end, and a series of international airways—for the conducting of traffic between nations—are being mapped out. During the day these flying routes will be indicated by a system of land signs, and at night-time they will be illuminated by signal lights. Such regulations will mean that the air traffic, say between Paris and Berlin and Paris and Madrid, will pass along prescribed routes. There are aerial smugglers to be reckoned with, and the Customs must fix specific halts for aircraft at the frontiers. Machines will be registered and numbered, of course, as are motor-cars and other vehicles, and all international flights rigidly supervised.

Naturally, there are difficulties which face the builder in making passenger aeroplanes of large size. He is confronted, indeed, with a new set of problems; but these are not insurmountable. Aerial engines of high horse-power—which are not yet obtainable, by the way—are a necessity. Then rising and alighting need to be studied. Present forms of landing-gear comprise wheels and skids; but, for very large craft, some special launching mechanism, such as an inclined slipway, may have to be considered. And there are new questions affecting propulsion, in big machines, which arise from the use of a series of propellers. Large craft, too, must have power to vary their speed when in the air, and this result will be obtained, probably, by extending or reducing their wing-spread.

But progress, it is clear, can only be effected safely by slow and logical stages

Machines must be made able to weather gales of wind, and be rendered free from the risk of engine failure when flying over land that is unsuitable for alighting.

But here a point should be made. The present-day aeroplane is still absolutely experimental, and may be likened to the first tiny craft in which men ventured upon the sea and were the sport of every storm. But compare those early cockleshells with the liners which cross the Atlantic, spurning waves aside. A similar comparison is permissible in regard to the aeroplane. From flimsy constructions of wood and wire, which marked the first era, machines will improve until they are big enough, heavy enough, and fast enough to combat any wind short of the fiercest gale.

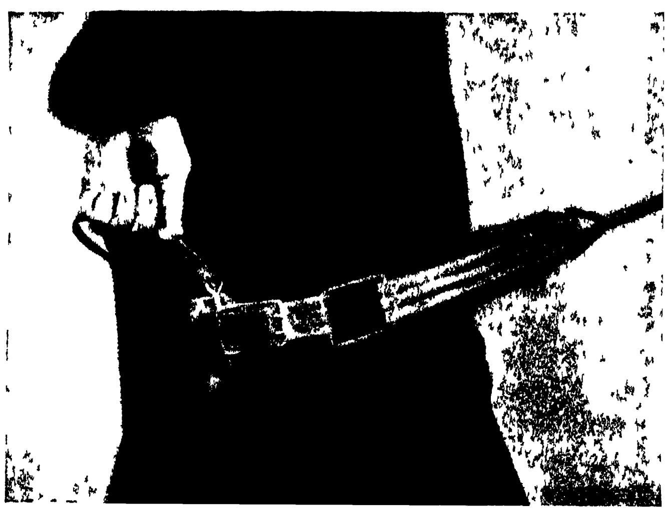


Photo supplied by Messrs A V. Roe & Co

The Airman's Safety Belt

It seems likely that the first passenger-carrying aeroplanes will be craft which have accommodation for twenty or twenty-five passengers; and these will be followed, in due course, by far larger machines. The luxury of air travel should become its outstanding feature. A journey by airway will be smooth, vibrationless, and restful to the nerves. Although immense speeds are attained, there will be nothing—save the hum of the wind along the polished hull—to tell the traveller that he is rushing through the air. Flying 10,000 feet high when on long, non-stop flights, machines will whirl ahead with effortless ease, the passengers seated in comfortable, totally-enclosed saloons, their view of the dim, far-distant earth obscured occasionally by a film of cloud.

But there is the problem of accident; can the navigation of the air be made safe? Fortunately, as opposed to the vague notion that flying must be perilous always, facts and figures may be adduced. In the very earliest stage of the science, when machines were crude and men unskilled, a distance of 150,000 miles was flown for the loss of only three lives; while in 1912, in France, there was but one fatality for every 92,000 miles traversed by air. Such statistics, at least, should nullify the impression that every time a man ascends in an aeroplane he runs the gravest of risks. With metal-built craft, constructed to withstand all shocks of flight, with the use of duplicate engines, and with suitable landing-grounds placed along flying routes, the navigation of the air will, as a matter of fact, be rendered reasonably safe. Machines have already ceased to collapse under the impact of abnormal wind-gusts; and as their safety increases steadily, so does their airworthiness too. Even now a well-built craft, when boldly handled, may be flown on 80 per cent. of the days of the year.

And so to a final word—which is this: when the aeroplane reaches its practical stage, there will come first a linking up of nations, and then of the entire world, until all humanity learns to revere the airmen who, braving ridicule and death itself, laid the foundation-stones of the science of flight

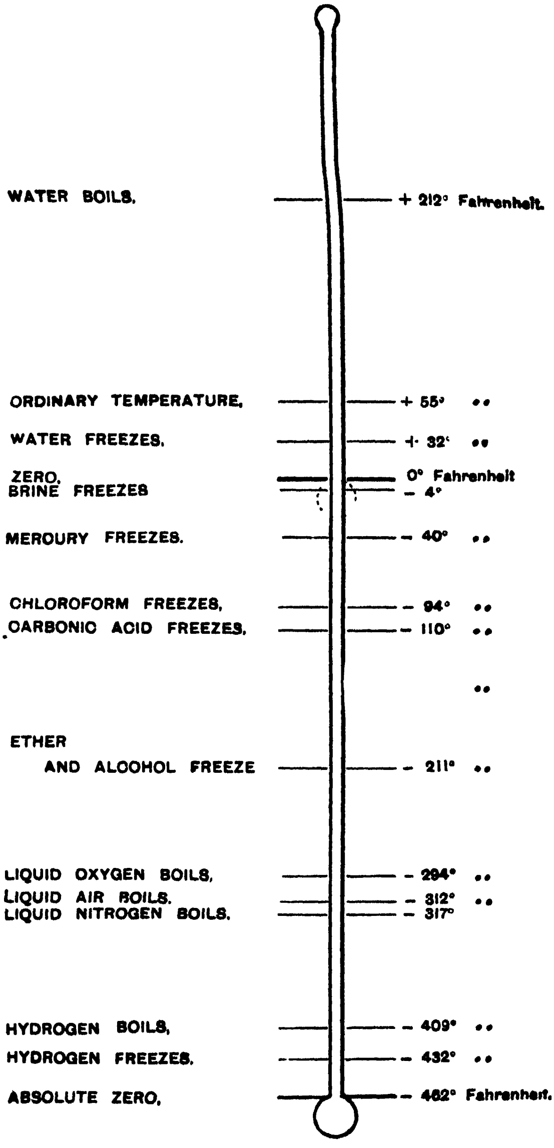
The Infinitely Cold

The Wonders of Liquid Air—How Scientists Produce Extremely Low Temperatures

By HOWARD TRIPP, M.A., Ph.D., F.C.S.

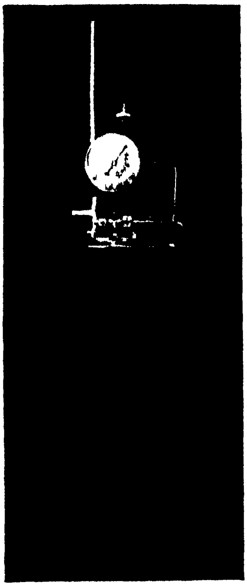
WHEN, with tightened face-muscles, you are bending low, pumping away at that deflated bicycle tyre, and your left hand experiences the increasing temperature of the pump, you are reminded, *nolens volens*, of the fact that the effect of compressing air is to heat it. The converse of this statement also holds good; when air or any other gas expands, it automatically cools itself. Advantage has been taken of this principle to liquefy air and also many other gases which were formerly thought to be "permanent"—i.e. incapable of condensation—and as a consequence, to produce such extremely low temperatures that the bitter cold of an Arctic winter is warm and congenial in comparison with them. To turn air into a liquid, it is compressed until its pressure is equal to 200 atmospheres, cooled down, and then allowed to expand suddenly so that its pressure is reduced to only 20 atmospheres. In this way the intangible, invisible mixture of gases which envelop our globe and make life possible is converted into a limpid but somewhat cloudy liquid, very much like water. The cloudiness is due to the presence of solid particles of carbonic acid and of ice, which may be easily removed by passing the liquid through a paper filter. It is, of course, necessary to guard against this fluid coming in contact with the skin, for its temperature is no less than – 292° F., and the consequences might be painful. For a short time the fingers may be dipped into liquid air with impunity, for the layer of ordinary air which envelops the liquid prevents for a time actual contact with the skin; but when that contact does take place the digits are at once atrophied and turned into hard, stiff, yellow objects somewhat like small petrified bananas—324 degrees of frost are not to be trifled with! The lowes temperature yet recorded in Nature is – 79° F. by Amundsen in Boothia (Canada); liquid air is over three and a half times as cold. Although comparatively easy to produce, condensed air is very difficult to preserve, as it rapidly boils away into gaseous air; but Sir James Dewar in England and D'Arsonval in France have devised special receptacles for this purpose. These are glass vessels surrounded with an almost perfect vacuum. On examining them we see two flasks, as it were, joined together at the top of their necks; between the two is practically nothing, for almost every trace of air has been removed. The presence of this vacuum round the inner flask prevents heat being conveyed to it by conduction, and the access of radiated heat is inhibited by coating the interior surfaces with a thin layer of silver. In such vessels as these, liquid air can be kept for weeks,

A weight suspended from a hook of mercury frozen solid by immersion in liquid air and the better the vacuum the longer the preservation. The very best vacua, which are obtained with the aid of liquid air itself and charcoal, contain such an infinitesimal amount of air that its pressure is only one ten-millionth of an atmosphere. The application of this principle of surrounding a vessel with nothing, or next to nothing, in the vacuum flask is well known to all. Our grandchildren will no doubt be witnesses of a much more extended utilisation of this brilliant idea. Refrigerators could be kept cold almost indefinitely, and greenhouses could be kept hot with a minimum expenditure on fuel. One can even conceive of a house built on this principle, and if it were applied to clothing, chills and other ailments caused by exposure to sudden alterations of temperature would cease to trouble; and, moreover, the presence of such a cold-protecting armour would entail a smaller consumption of food in winter. It is, at any rate, pleasant to consider even the possibility of some reaction against the ever-increasing cost of living. A vacuum flask, provided with one of these nearly perfect vacua, will preserve boiling tea and coffee so well that after four days they will still be too hot to drink. Hot liquids must be confined in closed, but ultra-cold ones always in open, vessels; otherwise, dangerous explosions will occur. When some liquid air is put into an iron tube closed at one end, and the other end is stoppered with an india-rubber bung, the latter is shot out with great violence almost instantaneously. The explanation is that the liquid evaporates very quickly, giving rise to a relatively enormous volume of gas; in fact, 1 cubic foot of liquid air gives 750 cubic feet of gaseous air. If some of our liquid be poured on to a block of ice, it boils away in a twinkling—ice is so hot compared with it—causing clouds of steam, which in reality consist of condensed water vapour and carbonic acid in the air outside. For a similar reason a kettle containing liquid air appears to boil when placed on ice, an experiment with which music-hall artists have made us familiar in the past. The intense cold of liquid air cannot be measured with a thermometer, for quicksilver, or even alcohol,



Thermometric Table

Showing the temperatures at which various substances congeal



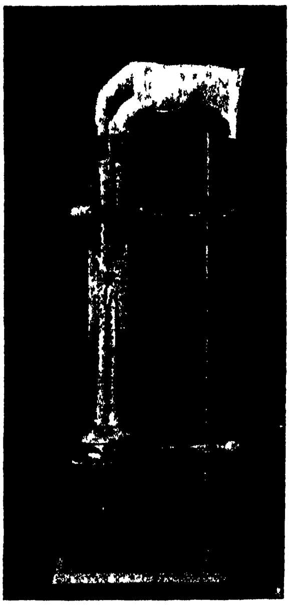
Apparatus for Producing Liquid Air

is frozen into a hard solid which expands and shatters its glass receptacle. Such low temperatures are measured with the same instrument that is used to determine very high ones — viz. with a pyrometer, for the electrical conductivity of a metal increases proportionately as the temperature is lowered. Copper, for example, conducts fifty times better at the temperature of liquid air than it does normally, and when cooled with liquid hydrogen down to — 422° F., a hundred times better. Could electrical engineers make use of these ultra-frigid liquids in the construction of cables, etc., an enormous reduction in cost would follow, but at the same time the depreciation in value of the red metal would strike panic into the hearts of those who buy, sell, or speculate in it.

Whisky Frozen to a String by Liquid Air

When quicksilver is frozen in a glass tube with the aid of liquid air, the hard metallic rod obtained can be used for driving nails into wood. When butter is immersed, it attains the hardness and compactness of bricks, and rubber tubing emerges from the ordeal as hard and brittle as a tube of glass. The tenderest and juiciest beefsteak, after treatment, is hard enough to break a plate; flowers become petrified and resemble porcelain; and cherries, strawberries, and other fruits must be manipulated with nutcrackers or with a hammer. Wool and felt also become hard and very brittle, and hence it has been suggested to get rid of old hats by plunging them into liquid air and giving them the *coup de grâce* with a hammer. Even a blacklead pencil refuses to write when chilled to — 290° F., and a red one turns black. Lead becomes sonorous, iron wire will support weights twice as heavy as at the ordinary temperature, and a lead wire of $\frac{1}{25}$-inch diameter will support a weight of 4½ lb. Perhaps the most remarkable way to show the intense frigidity of liquid air is to immerse in it a small metal ball supported by a string, and then to hold it in a hot gas flame, such as that of a Bunsen burner. The metal sphere is at once covered with ice, due to the freezing of the water-vapour contained in the flame.

We thus see that the properties of bodies are very radically altered at these very low temperatures, and we opine that, could they be exposed to the lowest artificial temperature ever obtained, — 452° F., still more miraculous changes would be observed. Even at — 292° the speed



A Glowing Match Blazes up when Plunged into Liquid Air of a photographic plate is reduced by 80 per cent., so lower down the scale photographic action would in all probability cease entirely.

Microbes seem to enjoy the relaxation afforded them by a bath of liquid air; they are apparently lulled to sleep by its soothing charm, and when subsequently awakened by a rise to normal temperatures, their activity is found to be in no way diminished. Seeds show a similar resistance to great cold, and this fact supports the theory that the germs of life may originally have been brought to the earth embedded in a meteorite, for the outer darkness and infinite cold of interplanetary space would not have impaired their vitality. In spite of the fact that the meteorite would be raised to a state of intense heat, or even of incandescence, by its rapid flight through our atmosphere, the enclosed germs need not necessarily suffer from the withering temperature of the "falling star," since, as explained on p. 944, many meteorites retain a heart of icy coldness, even in their flight through space.

It must not be thought that liquid air is a mere scientific toy, designed, like picture palaces and aerodromes, to satisfy our love of sensation. It has already been put to a number of useful purposes, and when it can be produced more cheaply its uses will be multiplied enormously.

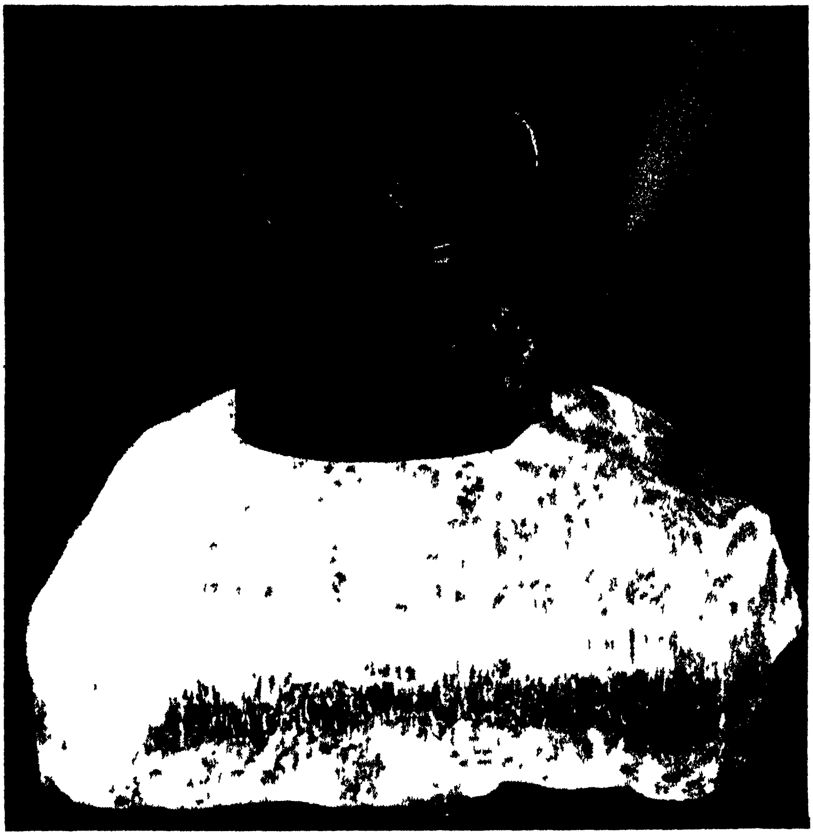


Photo Underwood and Underwood

Boiling a Kettle on Ice

When a kettle containing liquid air is placed on ice it "boils," because the ice is intensely hot when compared with the very low temperature of the liquid air

It has been used to cauterise wounds and to eradicate external cancers; it is employed as an explosive for blasting rocks; it has been most successfully used in chemical research, notably by Sir William Ramsay, who discovered several rare gases in the atmosphere with its aid. Probably the most important use of liquid air in industry will be as a means of separating the oxygen from the nitrogen contained in it. When liquid air boils, the nitrogen distils off first, leaving the oxygen still in the liquid state. The nitrogen so obtained is of 99·9 per cent. purity, and would be useful in the manufacture of nitrogenous fertilisers; and the oxygen (of about 80 per cent. purity) would be most usefully employed as a substitute for air in many industrial processes.

Sunrise at the South Pole

(Drawn by Scriven Bolton, F R A S)

Very, very slowly, yet surely, the rotation of the earth is slowing down. The time will ultimately come when, like the planets Venus and Mercury, our earth will always present one face to the sun. On the side farthest from the sun unending night will reign over a perpetually ice-bound land

Photo of Petra by American Colony, Jerusalem

The Barren Peaks of Petra

Sooner or later the day will lengthen out till one hemisphere of our planet is bathed in eternal sunshine, becoming a dry and barren desert of naked rock, dead from thirst and sunstroke

The Death of Our Planet

By ARTHUR HOLMES, A.R.C.S., F.G.S.

Author of "The Age of the Earth," &c.

FROM time to time various self-appointed prophets have foretold the coming of the end of the world, associating this supreme tragedy with the more portentous signs of the heavens, and even going so far as to fix the actual date of the catastrophe. A solar eclipse, the advent of a comet, a brilliant display of shooting stars: such are the innocent events which provide the superstitious fanatic with his terrifying stock-in-trade. But the earth persistently disappoints these cosmic pessimists, whose futile warnings have no better result than to provoke a few poor wretches to suicide.

The idea that the earth will one day be burnt up, merely betrays ignorance of the nature of combustion, and the suggestion of poisonous fumes lurking in the tails of comets can be taken no more seriously. If the earth did encounter a comet's tail, it would pass through the thin appendage quite imperceptibly, and nothing more startling would be seen than a fall of shooting stars—themselves the debris of a shattered world.

From the daily routine of the solar system the earth has nothing to fear but the frailties of old age. So well regulated is the sun's family that no accident from within can ever disturb its domestic peace. The danger of an unforeseen catastrophe which might suddenly threaten our planet with extinction lies entirely outside, for the sun, with the planets ever circling about him, is travelling through the open universe at the reckless speed of 40,000 miles an hour! What, then, is the chance that we may run into another celestial body?

One Thousand Million Suns

In the universe are 1,000,000,000 vivid suns coursing hither and thither with similar, or even more stupendous velocities, and the possibilities of collision seem appalling until we attempt to realise the immense arena of space in which the pageant of the stars is being played. The sparseness of their distribution then seems incredible. Even at the unthinkable speed at which we are being borne through space, 70,000 years would elapse before the sun's nearest neighbour could be reached. As far as we know, the line is clear for thousands of centuries ahead.

But what of the invisible wanderers which carry no head-lights? What of the countless hosts of "dark stars," so few of which can ever reveal themselves to us?

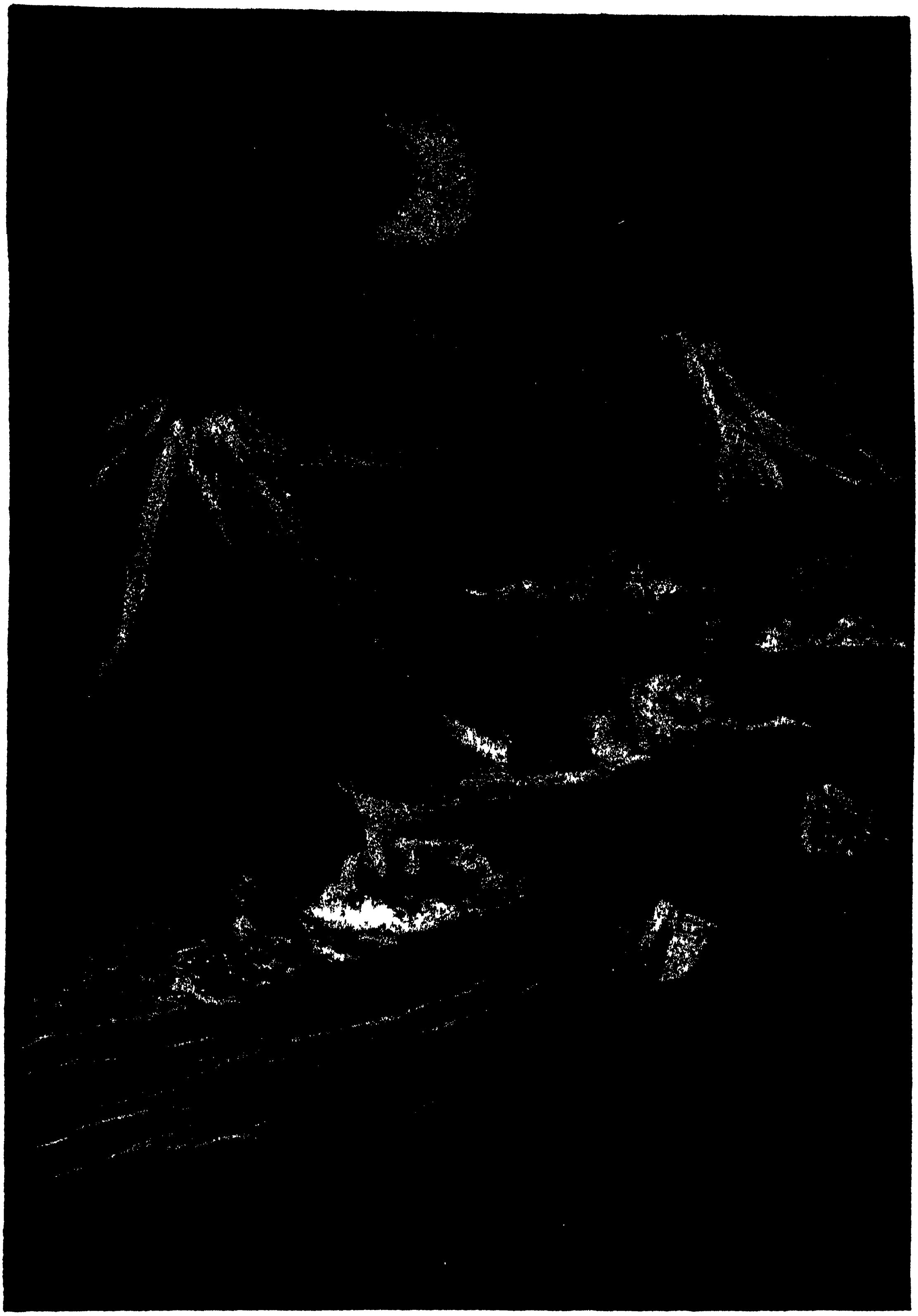
We know that such obscure bodies do exist, and in enormous numbers, just as we know that a bright and glowing fire will become cold and dark when it has spent its energies; and sometimes a star, previously unseen, blazes suddenly into view, rekindled to life by a chance encounter with another of its kind. Such outbursts rarely occur, and for one "new" star which leaps into brightness, indefinite multitudes remain dead and invisible.

It is just here that the menace lies. At any moment a "dark" star hitherto unsuspected may swing into the danger zone of our system. Let us suppose—distressing thought!—that a massive globe, careless of the tragedy before it, were to rush towards us with the sun as its ultimate goal. We might find ourselves in the way, but more probably in the awful chaos which would precede the actual collision we would be left on one side.

Our innocent but terrible enemy would loom out of the darkness as a tiny telescopic star, lit up by far-reaching gleams of sunlight; but long before its optical detection, the outer planets, Neptune and Uranus, would feel its irresistible attraction, and by their unusual behaviour would contrive to send us a wireless message heralding the approach of the invisible danger. If the star were travelling at about the same rate as the sun, some thirty or forty years would elapse before we should see it with the unaided eye. Rapidly growing in brightness and size, it would be watched with anxious eyes for a few more years until at last it reached the neighbourhood of the earth.

Return to Chaos

Its first effects would depend on the distance at which it approached and passed us. Demoralised by its attempts to obey two masters, the earth would already have begun to tremble violently in its orbit, and, finally, day and night, season and year forgotten, our planet would give itself up to the ever-changing dictates of the stranger. Then would begin the return to chaos. Enormous tidal waves would rise, sweeping over the plains and destroying the homes of men. Active volcanoes would be urged to unprecedented violence; extinct volcanoes would renew their dormant energies. Earthquakes would rend the face of the earth, and storms of unparalleled fury would complete the appalling destruction of life and property. At last, if the great orb came sufficiently near, the earth would be torn into fragments with all the violence of an explosion, returning after thousands of millions of years to the planetesimal chaos in which (see p. 3) it took its birth.



The Approach of a Dead Star Heralding the Earth's Return to Chaos

(Drawn by John R. Gauld)

Enormous tidal waves, the belching of volcanoes, fearful earthquakes, and storms of unparalleled fury would destroy life and property if a star passed near us on its way to the sun. Finally, if the great orb came too near, the earth would be torn to fragments with all the violence of a great explosion

Fortunately for our peace of mind there is, at the present moment, nothing to suggest the coming of any dark bodies more ponderous than the meteorites which are constantly bombarding the earth.

Thus fortified, we may turn in a calmer mood to contemplate the natural—as opposed to the accidental—causes by which the earth may die. Death in this sense implies the total cessation of every form of life, and although as yet the end is immeasurably remote, death in this fashion is as inevitable as that a stone left to itself will fall to the ground. The suitability of our planet as a habitation fit for life, as we know it, depends upon an amazing number of happy coincidences, such, for example, as the alternation of night and day, the proper limits of temperature, the circulation of water, and the particular composition of the atmosphere, all of which are now completely realised. If for any reason this delicate equilibrium were interfered with to the ultimate exclusion of one of the factors, death would swiftly follow.

Let us consider what would happen if day and night were to cease, each becoming a long forever. The sister planets, Venus and Mercury, have already arrived at this monotonous phase of their history. Just as the moon preserves an unchanging attitude towards the earth, so they turn ever the same face to the sun. As is well known, this curious behaviour is due to friction set up by the tides, which continually acts as a brake until the body presents to its master but one face perpetually. In this way the earth is undoubtedly slowing down, but so tardy is its response that in half a million years the day becomes only one second longer. Nevertheless, time has no limit, and sooner or later the day will lengthen out till one hemisphere is bathed in eternal sunshine, and the other in the frigid cold of an unending night. All the water of the globe would then gradually accumulate in the great fields of ice facing the outer darkness, and the sunlit side would speedily become a dry and barren desert. Life would be frozen to death, or die of thirst and sunstroke.

The second affection which leads to a planet's decease lies in its dependence on air and water. The earth may be continually losing the precious molecules which constitute its life-blood, for the utmost velocity which the earth can control is about seven miles per second, and as some of the molecules of oxygen and nitrogen and water-vapour exceed the speed limit, they must pass out into space, never to return. At present, we have every reason to suppose that the earth herself replenishes the loss, for some, at least, of the vapours and gases which issue from the vents of volcanoes and fumeroles come directly from the rocks. But as the source of supply becomes impoverished, the blankets of air and water which guard the earth from excessive heat and cold will gradually dwindle away. The moon has long ago been deprived of the flimsy atmosphere it may once have wrapped about itself, and among the planets, Mercury is in the same barren plight, while Mars, though still surviving, would appear to be slowly dying for want of breath.

On the earth, however, this action is so slow that probably long before it approaches completion death will have come in another way. The earth's life is intimately bound up with that of the sun, and, left to its own resources, its genial temperature would fall to more than 200° C. below zero. The dazzling brilliancy of our life-giving sun may endure for immeasureable millions of years, but death at last must come to it, as it has come to those hidden denizens of space which are whirling all about us. In the last gleams of the fading solar twilight our planet will disappear—a barren and frozen world. And of all the affections to which the earth is a prey, this, in the opinion of the writer, is the most likely to overtake her.

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ERRATA

On page 100, *E. meridianalis* should read *E. meridionalis.*

On page 183, acknowledgment *should read:* "Photo by the Bishop of Nassau."

On page 197, acknowledgment *should read:* "From a photograph in the possession of the Royal Anthropological Institute."

N.B.—Page 336, col. 1. The project for a power station on the banks of the Zambezi has not yet been put into execution. The current supplied to Johannesburg is generated at Vereening and at several smaller stations, such as Rosherville.

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